U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

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CRUISE REPORT[1]

VESSEL: *Hi'ialakai*, Cruise HI-07-02

CRUISE PERIOD: 12 May–22 May 2007

AREA OF OPERATION: Guam and the Commonwealth of the Northern Mariana Islands (CNMI: Rota, Aguijan, Tinian, and Saipan)

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED), Pacific Islands Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS), NOAA, and their partner agencies conducted coral reef assessment/monitoring and mapping studies in waters surrounding the islands of Guam, Rota, Aguijan, Tinian, and Saipan.

ITINERARY:

12 May — Start of cruise: Apra Harbor, Guam. Embarked Robert Schroeder (Chief Scientist), Marc Nadon (REA – Fish), Valerie Brown (REA – Fish), Jean Kenyon (REA – Corals), Bernardo Vargas Angel (REA – Corals), Allison Palmer (REA – Algae), Edson Limes (REA – Algae), Brian Zgliczynski (Tow Team – Fish), Benjamin Richards (Tow Team – Fish), Jacob Asher (Tow Team – Benthic), Edmund Coccagna (Tow Team – Benthic), Jamison Gove (Oceanography), Frank Mancini (Oceanography), Ellen Smith (Oceanography), Daniel Merritt (Oceanography), James Bostick (Divemaster/Chamber Operator), Russell Moffitt (Data Manager, Support Diver), Scott Ferguson (Mapping), Joyce Miller (Mapping), Jonathan Weiss (Mapping). Conducted dive safety briefings and chamber drills. Launched small boats for tow, oceanography, and Rapid Ecological Assessment (REA) Fish and Benthic teams; began research operations. Conducted two REA surveys and four towed-diver surveys (see Appendix for sites by island). Collected 14 shallow conductivity-temperature-depth (CTD) casts and 21 water samples at 5 sites. Acoustic Habitat Investigator (*AHI*) vessel departed wharf with Ferguson and Miller aboard to conduct mapping in Apra Harbor and outside of the harbor on

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the western side of Guam. Ship departed Apra Harbor, Guam, at ~1015 and commenced mapping, which continued throughout the day on the western side of Guam. A 500-m CTD cast was conducted after exiting the harbor. Recovered all small boats and *AHI* by 1700. Nighttime operations consisted of shipboard mapping and deep CTDs.

13 May — Continued operations at Guam, working along N and NW sides. Completed three REA surveys and six towed-diver surveys. Collected seven shallow water CTDs, eight water samples at two sites, and recovered/replaced two Subsurface Temperature Recorders (STRs) and one Sea Surface Temperature (SST) buoy. *AHI* completed surveying locally requested management target sites and from the N tip of Guam to Tumon Bay. (*AHI* experienced some computer problems.) The ship conducted mapping throughout the day, and night operations were initiated with shipboard mapping and deep CTDs.

14 May — Continued operations at Guam, working on N and E sides. Completed two REA surveys and four towed-diver surveys. Collected 13 shallow water CTD, 10 water samples at 2 sites, and deployed an EAR (Ecological Acoustic Recorder) and an STR along the NE. Ship conducted some mapping during the day. *AHI* mapped along the NW, N, and NE sides of Guam at areas of interest specified by Guam managers. Ship mapped during the day and initiated night operations with shipboard mapping and deep CTDs.

15 May — Continued operations at Guam, along E, SE, and SW. Completed three REA surveys and five towed-diver surveys. Collected 11 shallow water CTDs and 16 water samples at 4 sites and retrieved/replaced 1 STR. *AHI* was launched on the E side of Guam and began mapping near the University of Guam at a wave buoy site requested by University of Hawaii oceanographers and further south between 20 and 200 m. Ship conducted daytime mapping. Initiated night operations with shipboard mapping during transit from Guam to Rota.

16 May — Arrived at Rota. Commenced operations along NW and SE sides of island. Completed three REA surveys, and five towed-diver surveys. Collected 16 shallow water CTDs, 12 water samples (3 sites), and placed 2 STRs. *AHI* mapped the harbor and the NW side. Ship mapped the NE and E sides of Rota and continued mapping during the night.

17 May — Continued operations at Rota. Completed three REA surveys and five towed-diver surveys. Collected 13 shallow water CTDs, 10 water samples (2 sites), and recovered/replaced 1 SST and 1 STR in the bay. *AHI* conducted mapping surveys in the harbor and along the W coast. *AHI* crew spent the night ashore. Ship conducted mapping during the

daytime and nighttime. Departed Rota and began transit to Aguijan, mapping along the way.

18 May — Arrived at Aguijan. Commenced operations. Completed one REA survey, and three towed-diver surveys. Collected 19 shallow water CTDs, 12 water samples (3 sites), and recovered/replaced 1 STR. Departed Aguijan and transited to Tinian, arriving in the early afternoon. Completed one REA survey and two towed-diver surveys. Collected 15 shallow water CTDs and 9 water samples (3 sites). *AHI* shuttled Emily Lundblad from Tinian to ship; embarked Emily Lundblad (Mapping) and disembarked Scott Ferguson and Joyce Miller from *Hi'ialakai*. *AHI* operated independently for duration of the cruise while mapping Saipan Harbor and other nearby areas. Ship conducted multibeam mapping operations during the day and throughout the evening around Aguijan and southern Tinian.

19 May — Continued operations at Tinian. Completed three REA surveys along the W and E shores, and five towed-diver surveys along the NW and NE of Tinian. Collected 11 shallow water CTDs, 8 water samples (2 sites), and retrieved 1 STR and deployed 2 STRs. *AHI* mapped in Saipan Harbor and shipboard mapping was conducted off the NW and E sides of Tinian and in the channel. Initiated night operations with mapping around Tinian and Saipan. Departed Tinian and began transit to Saipan.

20 May — Arrived at Saipan. In the early morning, ship mapped while transiting to location ~10 miles east of northern Saipan to map at an offshore area of interest. Commenced operations along E side of island. Completed three REA surveys, and six towed-diver surveys. Collected 17 shallow water CTDs, deployed 2 EARs at REA sites, and deployed an anchor for a WTR (Wave and Tide Recorder). Ship mapped entire east side of island along 100-fathom boundary while *AHI* continued mapping in Saipan Harbor. Initiated night operations with multibeam mapping around Saipan.

21 May — Continued operations at Saipan along S and SW sides. Completed three REA surveys, and six towed-diver surveys. Collected 23 shallow water CTDs, 16 water samples (4 sites), and deployed 1 SST buoy and recovered/replaced 1 STR. *AHI* continued mapping in the harbor in conjunction with shore-based NOS/OCS personnel. Ship conducted some multibeam mapping during the day in deep water around the SE and during the night around the SE and E of Saipan.

22 May — Continued operations at Saipan. Completed two REA surveys, and four towed-diver surveys along the NW coast. Retrieved Coral Reef Early Warning System (CREWS) buoy in the harbor. Ship continued

to map around N Saipan and Marpi Bank and continued around W Saipan. *AHI* mapped in Saipan Harbor. Ship entered Saipan Harbor at 1200. Small boats returned to ship at the dock. End of cruise.

Table 1: Cruise statistics for HI-07-02 (including 1 day of Saipan and Tinian operations from HI-07-03).

	Guam 12-15 May	**Rota** 16-17 May	**Aguijan** 18-May	**Tinian** 18-19,25 May	**Saipan** 20-22,25 May	**GRAND TOTAL**
Towed-diver Habitat/Fish Surveys	**19**	**10**	**3**	**8**	**16**	**56**
Total tow length (km)	**45**	**23**	**8.4**	**17.5**	**37**	**130.9**
Fish Rapid Ecological Assessments	**10**	**6**	**1**	**5**	**8**	**30**
Benthic Rapid Ecological Assessments	**10**	**6**	**1**	**5**	**8**	**30**
Invertebrate collections	**3**	**2**		**1**	**2**	**8**
WTR deployed					**1**	**1**
SST buoys recovered	**1**	**1**				**2**
SST buoys deployed	**1**	**1**			**1**	**3**
STRs recovered	**3**	**1**	**1**	**1**	**1**	**7**
STRs deployed	**4**	**3**	**1**	**2**	**1**	**11**
CREWS buoys recovered					**1**	**1**
EARs deployed	**1**				**2**	**3**
Shallow water samples (Chl and Nutrients)	**55**	**22**	**12**	**17**	**16**	**122**
Deepwater sample profiles						**0**
Deepwater CTDs (from Hi`ialakai)	**8**	**3**	**1**	**3**	**5**	**20**
Shallow water CTDs (oceanography team)	**45**	**29**	**19**	**26**	**40**	**159**
Shallow water CTDs (AHI)	>>	>>	>>	>>	>>	**9**
Multibeam mapping (sq. km)	**1600**	**800**	*see Saipan*	*see Saipan*	**1800**	**4200**
SCUBA dives (approx Man*Dives)	**120**	**70**	**15**	**55**	**100**	**360**

MISSIONS:

A. Conduct ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (<35 m) coral reef ecosystems of Guam, Rota, Aguijan, Tinian, and Saipan.

B. Conduct benthic habitat mapping of the reefs and submerged banks surrounding Guam, Rota, Aguijan, Tinian, and Saipan using ship-based and launch-based multibeam echosounders and underwater towed cameras.

C. Deploy an array of SST buoys, STRs, and EARs to allow remote long-term monitoring of oceanographic and environmental conditions affecting the coral reef ecosystems of Guam, Rota, Aguijan, Tinian, and Saipan.

D. Collect water samples for analysis of nutrients and chlorophyll levels.

E. Conduct shipboard CTDs to a depth of 500 m, shallow water CTDs from small boats to a depth of ~30 m, and shipboard acoustic Doppler current profiler (ADCP) surveys around reef ecosystems to examine physical and biological linkages supporting and maintaining these coral reef ecosystems.

F. Determine the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.

G. Collect ADCP data during all transits.

H. Provide support as required for PIFSC and NOS/OCS personnel conducting shorebased nautical charting surveys of the harbors of Rota, Tinian, and Saipan.

RESULTS:

(See Appendices B through F for detailed survey summaries organized by island)

A. Ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (<35 m) coral reef ecosystems at Guam, Rota, Aguijan, Tinian, and Saipan was completed at 30 REA sites and 131 km of towed-diver survey transects.

B. Mapping from the *Hi'ialakai* and the survey launch R/V *AHI* resulted in the collection of high resolution multibeam bathymetry and backscatter imagery around Guam, Rota, Aguijan, Tinian, and Saipan.

C. Three SST buoys were deployed at Guam, Rota, and Saipan; 3 EARs were deployed at Guam and Saipan; and 11 STRs were deployed at Guam, Rota, Aguijan, Tinian, and Saipan to allow remote long-term monitoring of oceanographic and environmental conditions affecting coral reef ecosystems. Two SST buoys, one CREWS buoy, and seven STRs were recovered at Guam, Rota, Aguijan, Tinian, and Saipan.

D. One hundred twenty-two shallow water and 0 deepwater stations were visited to collect water samples for analysis of nutrient and chlorophyll levels.

E. Twenty shipboard CTDs to a depth of 500 m, and 9 shallow water CTDs from the *AHI* to a range of depths from ~50 to 200 m were completed.

F. The existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris were noted.

G. ADCP data was collected during all transits.

H. Support was provided as required for PIFSC and NOS/OCS personnel conducting shorebased nautical charting surveys of the harbors of Rota, Tinian, and Saipan.

SCIENTIFIC PERSONNEL:

Robert Schroeder, Chief Scientist, Joint Institute for Marine Research (JIMAR), University of Hawaii (UH)
Marc Nadon, Marine Ecosystem Specialist, JIMAR, UH
Valerie Brown, Biologist, Pacific Islands Regional Office, National Marine Fisheries Office
Jean Kenyon, Marine Ecologist, JIMAR, UH
Bernardo Vargas Angel, Coral Biologist, JIMAR UH
Allison Palmer, Biologist, National Park Service, Guam
Edson Limes, Biologist, Commonwealth of the Northern Mariana Islands/ Division of Environmental Quality
Brian Zgliczynski, Research Biologist, Pacific Islands Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS)
Benjamin Richards, Marine Ecosystem Specialist, JIMAR, UH
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Russell Moffitt, Atlas Coordinator, JIMAR, UH
Scott Ferguson, Lead Logistics Coordinator, PIFSC, NMFS
Joyce Miller, Oceanographer, JIMAR, UH
Jonathan Weiss, Seafloor Mapping Specialist, JIMAR, UH
Emily Lundblad, GIS Specialist, JIMAR, UH

DATA COLLECTED:

Fish REA numerical and biomass densities by species
Digital images of fish-habitat associations
Target REA macroinvertebrate counts
Macroinvertebrate voucher specimens
Algal voucher specimens
Coral voucher specimens
Coral REA numerical abundance and size class by genus
Digital still images of REA site characteristics
Digital still images of coral species
Digital video along transects at REA sites
Invertebrate voucher specimens
Algal REA field notes of species diversity and relative abundance
Digital images from algal photoquadrats
Quantitative towed-diver surveys of large fish species (>50 cm TL)
Digital video surveys of fish/habitat from towed-diver transects
Benthic composition estimations from towed-diver surveys
Macroinvertebrate counts from towed-diver surveys
Digital images of the benthic habitat from towed-diver surveys
Habitat lineation from towed-diver surveys
Shallow-deep CTD profiles
Water samples to be tested for cholorophyll and nutrient content
Dissolved inorganic carbon from deepwater CTDs
Raw and processed multibeam digital data

(/s/Robert Schroeder)
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Chief Scientist

(/s/Samuel Pooley)

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Attachments

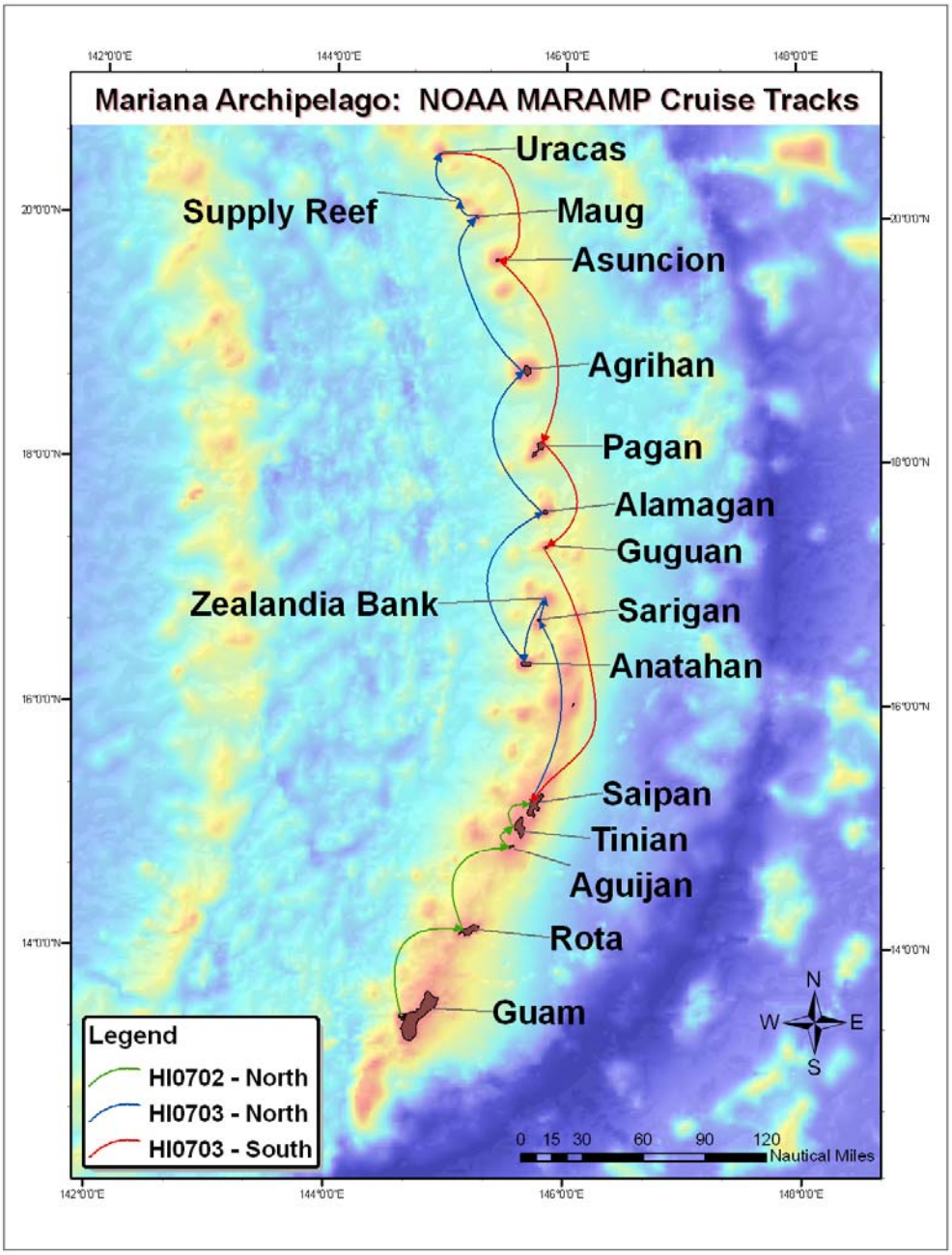

Figure 1.--Track of NOAA ship *Hi'ialakai* during cruise HI-07-02 around Guam, Rota, Aguijan, Tinian, and Saipan, 12-22 May 2007.

Appendix A: Methods

A.1 Benthic Habitat Mapping Methods

(Joyce Miller, Scott Ferguson, Jonathan Weiss, Emily Lundblad, Senior Survey Technician Jeremy Taylor)

System Descriptions

Multibeam mapping capability for cruise HI-07-02 included two shipboard multibeam echosounders (Kongsberg EM300 and EM3002D) and the Reson 8101ER multibeam aboard the 8-m launch R/V *Acoustic Habitat Investigator* (*AHI)*. Table A.1-1 provides an overview of the three multibeam sonars and their capabilities.

Table A.1-1. Sonar System Capabilities.

Sonar	Vessel	Freq. (kHz)	Depth Range (m)	Beam Size (deg)	Number of Beams
EM300	*Hi'ialakai*	30	30-3000	1 ½ x 1 ½	135
EM3002D	*Hi'ialakai*	300	2-150	1 x 1	320-508
Reson 8101ER	*AHI*	240	2-250	1 ½ x 1 ½	101

In addition to the multibeam sonars, each vessel is equipped with an Applanix Position Orientation Sensor for Marine Vessels (POS/MV) vertical reference system, which provides timing, position, velocity pitch, roll, heave, and heading information for correction of motion in the multibeam data. Three different conductivity-temperature-depth (CTD) sensors were used to provide sound velocity profiles (SVPs) that are critical for proper correction of sound velocity errors associated with multibeam data.

All sensors on both vessels were interfaced to the SAIC ISS-2000 data acquisition and survey control system, which includes survey planning, data acquisition, and data processing capabilities.

During the 2006/2007 winter yard period, the main mast on the *Hi'ialakai* was replaced, and the POS-MV antennae were relocated. These changes necessitated a recalibration of the multibeam system, including entry of new antennae offsets in the POS-MV software, performing a POS-MV GAMS calibration, and running of patch tests. The GAMS calibration and EM300 patch tests were done on April 2-3, 2007, and the patch test for the EM3002D sonar was completed on April 19-20, 2007 to determine new bias parameters for entry into the EM300 and EM3002 software. These tests are documented in the *Hi'ialakai* Patch Test update, "Summary of April 2007 Patch Test Results: NOAA Ship *Hi'ialakai*: EM3002D and EM300 Multibeam Sonars."

Vessel offset and patch tests for the R/V *AHI* were also conducted with the cooperation of Office of Coast Survey representatives, Lt. Mark Van Waeas and Erin Campbell, Physical Scientist. These patch tests were performed during the week of March 12–16, 2007, in Honolulu in preparation for collaborative harbor charting surveys in CNMI that

are planned during HI-07-02. Two reports that document the R/V *AHI* tests are "Report on Vessel Offsets for R/V *AHI* (F2505)" and "Hydrographic Survey Readiness Review (F2505)".

Methods for acquisition and post processing

Prior to the cruise, existing bathymetry data were assembled to provide a baseline for acquisition of multibeam data. These data included (1) Simrad EM300 multibeam bathymetry collected aboard the R/V *Thompson* during the NOAA Ocean Exploration Ring of Fire cruises in 2003 and 2004; (2) Hydrosweep DS2 (HS-DS2) multibeam bathymetry collected aboard the R/V *Maurice Ewing* during cruises EW0202 and EW0203; (3) Hawaii MR-1 bathymetry collected aboard the R/V *Herman Melville* during cruises COOK06MV and COOK07MV; (4) and SeaBeam 2000 multibeam data collected aboard the R/V *Herman Melville* during the NOAA Ocean Exploration Submarine Ring of Fire cruise in 2006 and the COOK0107 cruise. Additionally, IKONOS imagery for all islands (if available), LIDAR bathymetry for Guam, and predicted tides for Guam Island station 1630000 were assembled. These data were used to create preliminary survey plans that were integrated into the ISS-2000 software before the cruise. These data were also assembled and integrated into the Arc 9 Geographic Information System (GIS).

The ISS-2000 survey system is used on both the ship and the launch, enabling seamless sharing of data between the two vessels. The Generic Sensor Format (GSF), which is implemented in the ISS-2000 system, allows logging of multibeam data from a variety of multibeam sonars into a single, standardized format; the GSF also provides integrated metadata within the real-time multibeam files. In addition, the ISS-2000 creates digital message logs that allow full traceability of software and real-time events.

During system configuration, all vessel offsets are entered into either the POS/MV, the sonar, or into the ISS-2000. In addition, predicted tides are calculated for all tide zones to be surveyed and then recorded into the data in real time. Survey plans can be loaded into the real-time system on both vessels; coverage grids that are generated in real time during data acquisition can be viewed during planning, acquisition, and processing phases.

Sound Velocity Profiles (SVPs) are taken at the beginning of each 12-hour period of surveying on the ship and each 8-hour day of surveying on the *AHI* or as needed when the multibeam data indicate that a new SVP is needed. Standardized survey procedures, including a 2-minute warm up on deck and a 2-minute surface equilibration, are used on every cast. After the sound velocity cast is done, the data are downloaded with VelocWin software on the ship and with the SeaBird software on the launch. Sound velocity profiles are loaded using the ISS-2000 download utility; the downloaded profiles are sent to the two Kongsberg sonars on the ship and to the Reson sonar on the *AHI*, and the sound velocity information is logged as a part of the GSF. A real-time probe is used on the ship to monitor the surface sound velocity (SSV); if a difference between the SSV and the SVP at the surface is greater than 3 m/sec, an alarm is generated. The sonar on the *AHI* is less susceptible to SSV errors, and the daily casts

are generally sufficient to correct for sound velocity. In all cases, the data are carefully monitored for sound velocity artifacts using the real-time displays.

During real-time operations, the ISS-2000 operator starts the ISS-2000 software, making sure to load the appropriate system configuration file. The System Control and Message windows are loaded at that time. The operator creates a dataset for the entire cruise that is named with the corresponding cruise delineator; *Hi'ialakai* and *AHI* data were logged into separate datasets (HI0702 and AHI0702) for file management purposes. After the dataset is created and all configurations are checked, "Start Survey" is selected and the Navigation Manager, Multibeam Manager, and Helm Display windows are opened. Text icons for all programs appear in the System Control window; the icons can be colored white, yellow, red, or green. White means that the program is selected but not activated; yellow means the program is activated but not logging; red means that there is a problem with the program; and green means that the program is operating and data are being logged. Files are automatically created for all multibeam sensors, for navigation inputs, for the POS/MV vertical reference, and for the messages generated by the system. Predicted tide files that can be used throughout 2007 were prepared before the cruise and were applied to the multibeam data in real time.

After the ISS-2000 Navigation Manager is started, a survey plan is chosen and one or more surveys are selected for execution. Tide zones, existing coverage grids, and navigational charts can be loaded into the display, if desired. The navigated ship icon appears on the screen. Survey lines are then selected from the survey file or made in real time and loaded into a Survey Schedule; lines can be selected in any order and their azimuth can be reversed; these lines appear on the screen when loaded into the schedule. When survey lines are being run in Survey Mode, the multibeam data is almost always logged (if logging is activated), but may be flagged as either "online" or "off-line." During transits, survey can be done in the "Underway Mode," but a flag must be set to not flag the off-line data during transits. If a coverage grid is loaded using the Coverage Monitor program and enabled for real-time logging, multibeam data are added to the coverage grid in real-time.

The Helm Display is also activated when the survey is started. This Helm Display appears both on the survey lab screens and on a screen on the bridge, and screen display parameters can be manipulated at either location. The same coverage grids, navigation charts, and survey lines selected in the Navigation Manager interface appear on the Helm Display as well; however, the display of these grids, charts, and lines can be turned on and off in the Helm Display independently of the Navigation Manager. The Helm Display can also be changed to different scales and color schemes than what is displayed on the Navigation Manager. The ISS-2000 feature, display of the coverage grids on the Helm Manager, enabled the bridge to steer lines in underway mode based upon existing coverage rather than always needing to create a formal survey line for the bridge to follow.

The Multibeam Manager is used to monitor the status of data files, to view and apply SVPs, and to view the multibeam bathymetry and backscatter data in real time. Many

problems with the data can be detected immediately using feedback from these real-time displays. The Kongsberg SIS interfaces for the EM300 and the EM3002 are mounted above the two ISS-2000 screens, and other multibeam displays that provide different views of the data are available through SIS. Backscatter displays for all systems showed distinct and intriguing bottom types, but the ultimate quality of the data from the different sonars cannot be evaluated until data processing is complete.

During HI-07-02 multibeam data were collected around the clock aboard the *Hi'ialakai*. Deeper water mapping was usually conducted at night and daytime operations occurred closer to shore, with a focus on delineating the 100-fathom boundaries around all of the islands. Due to the steep nature of many of the islands, the Simrad EM300 was the primary multibeam used to map depths between 100 m and 3000 m. The Simrad EM3002 was used only as the ship entered and departed Apra Harbor, Guam and as the ship entered and departed Saipan Harbor to map depths between 15 and 200 m.

The *AHI* was deployed for 4 days at Guam and for 2 days at Rota and data collection was concentrated in the depths between 10 and 300 m. No *AHI* mapping was conducted at Aguijan. The *AHI* was deployed independently to do nautical charting work with Office of Coast Survey personnel at Rota, Saipan, and Tinian.

Aboard ship, data were logged to two disks simultaneously in real time. The ISS-2000 AutoArchive program, which copies the data to a third permanent archive disk was run as needed during post processing. The AHI0702 dataset was logged on the real-time computer in the launch, and a second copy of the data was manually made on a portable disk; the disk was then moved to the ship and connected to the shipboard computers, and the data were read to the permanent archive disk. A final copy of all data was made to the PIBHMC network disks, and data processing was done on only this copy of the data. The SABER data processing package, which provides full multibeam processing capability, was primarily used to manually edit the multibeam data in GSF, to plot tracklines, to update SVPs and tide data when necessary, and to create gridded data sets using the Pure File Magic (PFM) format that enables editing the integrated data set within the grid as well as reading any edits made in the grid back to the GSF multibeam files. CUBE, a recently implemented SABER software module that provides error estimates on the integrated data files and a more automated procedure for cleaning of the data set, was installed and tested with the new SABER version (4.0.14) installed on this cruise. Tape backups of all processed data were made approximately every 2 days. The gridded data sets were converted to ASCII files for conversion to Arc raster grids. Map products were made as grids were created and added to the GIS product archive.

Backscatter data are logged as part of the GSF multibeam file and will be processed at PIBHMC after return to Honolulu.

A.2 Oceanography and Water Quality

(Jamison Gove, Daniel Merritt, Ellen Smith, Frank Mancini, Senior Survey Technician Jeremy Taylor)

The Coral Reef Ecosystem Division (CRED) has been conducting oceanographic research throughout the Hawai'ian Archipelago and the U.S. remote Pacific Territories since 2001. Research around the Marianas Archipelago was first conducted in 2003. CRED's oceanographic investigations include in situ surveys and the deployment and recovery of instrument platforms to monitor and assess important physical, chemical, and biological variables in the coral reef ecosystem. Due to logistical constraints, visits to the Marianas region have been limited to every 2 years. Long-term oceanographic monitoring is accomplished via moored instrument platforms that internally record data and/or telemeter data via satellite.

Knowledge of oceanographic conditions and water quality at islands and banks in the Marianas Archipelago is fundamental to understanding the structure and function of coral reef ecosystem dynamics such as reef morphology, larvae distribution, productivity, species richness and diversity, growth rates, and overall ecosystem health.

The following in-situ oceanographic monitoring activities were conducted:

1. Shallow water (~30 m water depth) conductivity (salinity), temperature, and depth (CTD) profiles, including transmissometry (water clarity) measurements were conducted at regular intervals around Guam, Rota, Aguijan, Tinian, and Saipan, providing information on small scale distributions of water masses, circulation, and local seawater chemistry changes (Table A.2-1).
2. Shallow water chlorophyll *a* and nutrient samples were collected at 1 m, 10 m, 20 m, and 30 m at selected CTD sites around each island linking water quality with water masses and providing insight into localized nutrient enrichment and/or eutrophication.
3. Shipboard (> 500 m water depth) CTDs and acoustic Doppler current profiler (ADCP) transects were taken at a single latitude, traveling East and West from the latitudinal mid-point of each island. This provides information on the oceanographic structure upstream and downstream of each island. Dissolved oxygen, chlorophyll *a* and nutrient samples were taken at each Shipboard CTD station (Table A.2-2).
4. Shipboard chlorophyll *a* and nutrient samples taken at 3 m, 80 m, 100 m, 125 m, and 150 m at shipboard CTD locations east and west of each island. This provides ground truth information for the CTD profiles as well as insight into local nutrient levels and local carbon cycles.
5. Continuous recording of surface and subsurface water temperatures as a function of depth during all towed-diver operations, providing a broad and diverse spatial and thermal sampling method. Refer to the Towed Diver Habitat/Fish Survey Team Activity summary information.

Long-term oceanographic monitoring was accomplished by deploying a variety of both internally recording and near real-time telemetered instrument platforms and oceanic drifters. For Guam, Rota, Aguijan, Tinian, and Saipan these instruments included (Table A.2-2):

1. Sea Surface Temperature (SST) Buoys that measure high-resolution water temperature. These buoys telemeter their data in near real time.
2. Environmental Acoustic Recorders (EAR) that record sounds produced within the deployment region to listen for human activity, including boat traffic, and ambient biological sounds.
3. Subsurface Temperature Recorders (STR) that measure high-resolution subsurface temperatures. STRs are deployed around the island, including on the SST and EAR anchors.
4. Coral Reef Early Warning System (CREWS) Buoy that records subsurface water temperature and conductivity, sea surface wind direction and magnitude, ambient air temperature, barometric pressure, and both surface and subsurface Photosynthetically Active Radiation (PAR) and UV radiation.
5. Wave and tide recorder (WTR) that measures water pressure (waves and tides) and water temperature.

All moorings, shallow water CTDs, and shallow water samples were collected from a small boat during daylight hours.

Table A.2-1: Shallow water Oceanographic Sampling Summary

Site	CTD Sites	Water Sample Sites	Chlorophyll samples collected	Nutrient samples collected
Guam	45	13	55	55
Rota	29	5	22	22
Aguijan	19	3	12	12
Tinian	26	5	17	17
Saipan	38	4	36	36

Table A.2-2: Oceanographic Moorings Summary

Site	STR	SST	EAR	CREWS	WTR	Comments
Guam	4	1	1	0	0	One new STR and one new EAR were deployed at Guam
Rota	3	1	0	0	0	Two new STRs were deployed at Rota
Aguijan	1	0	0	0	0	
Tinian	2	0	0	0	0	One new STR was deployed at Tinian
Saipan	4	1	2	0	1	One new SST, one new WTR**, two new EARs and three new STRs were deployed at Saipan. One CREWS buoy was retrieved and not replaced at Saipan.

Note: ** This WTR was deployed as part of collaborative work with Mark Merrifield in the Department of Oceanography at the University of Hawaii at Manoa.

A.3 Rapid Ecological Assessment Methods

(Fish: Robert Schroeder, Marc Nadon, Valerie Brown; Corals: Jean Kenyon; Coral Disease: Bernardo Vargas Angel; Algae: Allison Palmer and Edson Limes; Invertebrates: ad hoc participants)

The survey methodology used during HI-07-02 was the same as previous rapid ecological assessment (REA) surveys conducted by CRED cruises. At each REA site, three 25-m transect lines were laid out by the fish team, separated from each other by approximately 3–5 m. At most sites, transects were laid out at 12–15 m (40–50 ft) depth. REA methods for each specific discipline are as follows.

A.3.1 Fish

The REA Fish Team conducted three types of surveys at REA sites: Belt Transects (BLT), Stationary Point Counts (SPC), and Roving Diver Rapid Ecological Assessments (REA). BLTs were performed along three consecutive 25-m lines set along a single depth contour. As each line was set, two observers swam about 2 m apart along either side of

the line, identifying to the lowest possible taxon, counting, and recording size classes for all fishes >20 cm total length (TL) within an area 4 m wide and 4 m high. At the end of each 25-m line, the divers turned around and returned along their respective sides of the line identifying, counting, and recording size classes of all fishes <20 cm TL within 2 m of their side of the line and 4 m off the bottom. The third fish team diver simultaneously conducted four SPCs at each REA site, generally ~15 m from the transect line. SPCs consist of the diver identifying, counting, and recording the size classes for all fishes >25 cm total length observed in a cylindrical volume 10 m in radius during a 5-minute period. Following and opportunistically during the BLT and SPC surveys, all three fish team divers recorded the presence of all fish species seen outside the transect area and outside the SPC counts. The fish REA team's species presence records were combined with fish species observed by other divers (benthic team, tow team, or oceanography team) to develop an island-wide record of all fishes observed. No collection efforts were made by the fish REA team during HI0702.

A.3.2 Algae

Standardized quantitative sampling methods for remote tropical Pacific islands were developed and published for marine algae (Preskitt et al., 2004). To allow for vertical sampling in areas of high relief (walls), the method was modified slightly by Vroom *et al.* (in review, Coral Reefs) and entails photographing quadrats, collecting algal voucher specimens, creating in situ algal species lists, and ranking relative algal abundance. This modified "Preskitt method" has been used by CRED since 2003 in the Northwestern Hawaiian Islands, Guam/Mariana Islands, Pacific Remote Island Areas, and American Samoa.

Macroalgae were tentatively identified to genus (species-level when possible) in the field, and ranked abundance of algal genera was collected from 12 quadrats (0.18 m^2) at each site (1 being the most abundant, 2 being the next most abundant, etc., with 10 being the maximum number of genera found in a single quadrat). Six quadrats were located at random points along the first two transects (3 per transect), and six quadrats were located at points 3 m perpendicular from each random point, in the direction of shallower water. Additionally, samples of macroalgae present within each quadrat were collected as voucher specimens (Preskitt et al., 2004) for microscopic analysis and species verification. A random swim at the end of each dive and between quadrats augmented macroalgal collections attained from quadrats and allowed cryptic species that predominantly occurred in shaded areas to be qualitatively recorded and collected. Because of difficulties with identification, algae that fell within the functional groups of turf, cyanophytes and crustose coralline algae were usually lumped into their respective categories.

A.3.3 Corals

At each site, the first two transect lines laid by the fish team served as the focal point for coral quantitative studies. Both transect lines were videotaped, including a 360^o pan at the beginning, middle, and end of each video-survey. Then, working in the reverse direction

along the transect lines, each coral whose center fell within one half meter of either side of the transect line was assigned to a genus and one of seven size classes: 1-5 cm, 6-10 cm, 11-20 cm, 21-40 cm, 41-80 cm, 81-160 cm, and >160 cm based upon a visual estimate of the identification and long diameter of each coral. For all but a few sites, corals were completely censused along both lines, but in some cases, time was not sufficient to complete the census. In these latter cases, the length of the lines actually censused was recorded and used to establish corrections to allow for comparisons with coral census data from other sites. The above data were used to compile generic richness, frequency of corals (no. per m^2), total number of colonies per taxon, proportion of total by taxon and to plot the size distribution of corals at each site. Lastly, a larger area outside the belt transects was examined according to the amount of time remaining for the occurrence of any additional taxa that did not occur within the belt transects.

A.3.3.1 Percent benthic cover

Only the first two, 25-m transect lines, previously laid out by the fish team, were surveyed for percent cover of benthic elements. Transect lines were previously labeled at 50-cm intervals. As the scientist swam along the transect lines, he inspected the benthic elements falling directly underneath each 50-cm mark on the transect line. Each such element was tallied and recorded to the lowest taxonomic level possible and then classified under the following scheme: live coral, dead coral, carbonate pavement, coral rubble, sand, rock, macroalgae, and other. These data are used to provide the basis for quantitative estimates of live coral cover, as well as percent cover of the diverse benthic and substrate components.

A.3.3.2. Coral health and disease assessment

At each site, using the first two transect lines laid by the fish team, an area of 3 m (depending on bottom time) on each side of the transect lines (approx. 300–400 m^2) was surveyed to document occurrence of coral bleaching and/or disease. Within this survey area, each diseased/afflicted coral colony was identified to the lowest taxonomic level possible, and the following information was recorded: (1) colony size; (2) type of affliction [bleaching, skeletal growth anomaly, tissue loss/white syndrome, trematodiasis, necrosis, other: coral-algal interactions with pigmentation responses, and cyanobacterial infections]; (3) area affected (percent live/dead); (4) severity of the affliction (based on the number of polyps affected, and the possible effect on the overall ability of the colony to function normally; and ranked as follows mild: 1; moderate: 2; marked: 3; severe: 4; and acute: 5); and (5) photographic records and tissue samples were procured as needed. Tissue samples were catalogued and fixed in buffered, zinc-formalin solution for further histopathological analyses. The disease data together with coral colony densities estimated by the second coral biologist will be used to estimate disease prevalence; samples and photographs will be used to aid in further disease characterization.

A.3.4 Macroinvertebrates

No standard macroinvertebrate surveys were conducted during HI-0702. All dive teams performed opportunistic Crown-of-Thorns Starfish (COTS) collection as described below.

A.3.4.1 Crown of Thorns Collection

Tissue samples from *Acanthaster planci* (COTS) were collected during HI-07-02 and HI-07-03 to examine the connectivity of COTS in the Central Pacific using mitochondrial DNA and gene flow analysis.

Previous studies conducted on the urchin, *Echinothrix diadema*, and the soldierfish, *Myripristis berndti*, found high gene flow between the Line Islands and the Hawaiian Archipelago. A study conducted on the flame angelfish, *Centropyge loriculus*, found high gene flow between the Line Islands, Johnston Atoll, and Hawaii. Together these studies provide clear evidence that connectivity exists between Hawaii, Johnston, and the Line Islands. Molly Timmers, a researcher at the University of Hawaii, is currently examining connectivity among COTS populations, specifically testing the hypothesis that the outbreak levels at Kingman and the increasing numbers present at Johnston of this highly fecund starfish could potentially seed an outbreak along the Hawaiian Archipelago.

Several theories exist that gene flow is present between the Northwest Pacific and the Northwestern Hawaiian Islands (NWHI) via eddies spinning off of the Kuroshio Current or from the Kuroshio Extension Current. The presence of fish such as the Japanese angelfish, *Centropyge interrupta*, suggests such a connection exists since this fish is known only in Japan, Taiwan, and the NWHI. To date, few genetic studies have been conducted to examine gene flow between the NWHI and the Northwest Pacific. A secondary aspect of the COTS research, in collaboration with a Japanese research group, is to examine *Acanthaster* gene flow between Japan, NWHI, and possibly the Marianas.

Based on towed-diver surveys from 2005 at Pagan and Guguan, where large populations of adult COTS and some juveniles were observed, populations levels at these islands may be high once again in 2007.

Ideally for microsatellite analyses it is best to have 50 individuals and for mtDNA to have 25 per island, or, for the larger islands, these numbers per east/west side. While such numbers may be difficult to achieve, all dive teams during HI-07-02 and HI-07-03 had COTS sampling kits onboard to be used opportunistically, either during other survey operations or after normal operations had been completed. At some REA survey sites, one diver was deployed to search solely for *Acanthaster*.

To collect the tissue samples for microsatellite and mtDNA analysis, divers used a knife or shears to remove one arm from an individual *Acanthaster planci* starfish near the base. These arms were then handled using tongs and placed in a hard plastic container. Collected samples were placed in EtOH back on board the ship to preserve the DNA for analysis. Samples from the same dive site were stored together in pint jars and 50-ml falcon tubes. Site metadata were recorded for each sampling location, including latitude and longitude, location name, collocation with another survey site, and general observations about the individual when it was collected. Containers were labeled with the year, four-digit #, and three-digit island code, e.g., 07_0001_GUM.

A.4. Towed-diver Survey Team Methods

(Jacob Asher, Edmund Coccagna, Brian Zgliczynski, Benjamin Richards)

Shallow water habitats were surveyed using pairs of towed divers on towboards equipped with a downward high resolution digital still camera with dual strobes (benthic towboard) and forward-looking digital video camera (fish towboard) to quantify habitat composition and complexity and abundance and distribution of ecologically and economically important fish and macroinvertebrate taxa. The downward-looking camera was maintained 1-2 m off the bottom and was programmed to photograph benthic substrate every 15 seconds. The diver on the benthic towboard observed and recorded habitat composition (hard coral, stressed hard, soft coral, macroalgae, coralline algae, sand and rubble) and tallied conspicuous macroinvertebrates (COTS), urchins, sea cucumbers, and giant clams) along a 10-m swath. The diver on the fish towboard recorded fish greater than 50 cm total length along a 10-m swath in 5-minute segments for a total of 10 segments (50 minutes). Species of particular concern observed outside the survey swath were classified in presence/absence data recorded separately from the quantitative swath data. Tow surveys were between 1.51 km and 4.33 km in length with a mean of 2.28 km. Both towboards were instrumented with precision temperature and depth recorders (Seabird SBE39). Global Positioning System positions, temperature, and depth were recorded every 5 s along each transect. The data were downloaded, processed, and presented in ArcGIS and overlaid on high resolution IKONOS imagery, NOAA chart data, and/or other spatial data layers.

Appendix B: Guam

B.1. Benthic Habitat Mapping

During HI-07-02 multibeam mapping surveys were conducted at Guam using the R/V *AHI*'s Reson 8101ER, and the *Hi'ialakai's* EM300 multibeam sonars. The *AHI* was deployed for 4 days and the *Hi'ialakai* surveyed for 4 nights and 4 days; total coverage at Guam was ~1,600 sq. km in water depths between 10 and 2,600 m (Fig. B.1-1). Features of interest mapped at Guam include a number of priority areas designated by Guam governmental agencies including the Department of Agriculture, the Environmental Protection Agency, the Coastal Management Program, the Guam Power Authority, the U.S. Fish and Wildlife Service, the Pacific Islands Regional Office (PIRO) Habitat Conservation Division, and private citizens. We succeeded in mapping the Ritidian Wildlife Refuge on the N tip of Guam, the Tumon Bay, Piti, and Achang Marine Preserves on the NW, W and S coasts respectively, two sewer outfalls on the W coast, and a sewage water air-conditioning target area on the W coast. Portions of Pago Bay were mapped, where the University of Guam Marine Lab and fish hatchery are located, and a small amount of *AHI* data were collected by request in the vicinity of a University of Hawaii Oceanography Department wave buoy.

Prior to HI-07-02 only a small amount of multibeam data, collected by the *AHI* in 2003, existed on the N tip of Guam. After the cruise, nearly all of the seafloor from 200 to 2000 m were mapped. These data reveal numerous features of geologic interest such as small blocks of material on all sides of the island that are most likely pieces of debris related to mass wasting. Very few canyons are present on the flanks of Guam, and the submarine morphology of the southern half of the island is significantly different than the northern half. The former is generally characterized by gradual slopes whereas the latter, especially in the SW, is characterized by steep slopes that reach depths >2,000 m immediately adjacent to the island. The seafloor adjacent to Orote Peninsula and Apra Harbor is highly complex and steps down along a series of interweaving scarps. Submarine terraces are present at a variety of depths in shallower waters around Guam.

Small amounts of multibeam data were also collected in Apra Harbor, Guam at the request of NOAA PIRO Habitat Conservation Division. These preliminary data are shown in Figure B.1-2. Final results of the R/V *AHI* mapping work conducted with Office of Coastal Survey representatives inside the harbors at Rota, Saipan, and Tinian will be presented in a separate report.

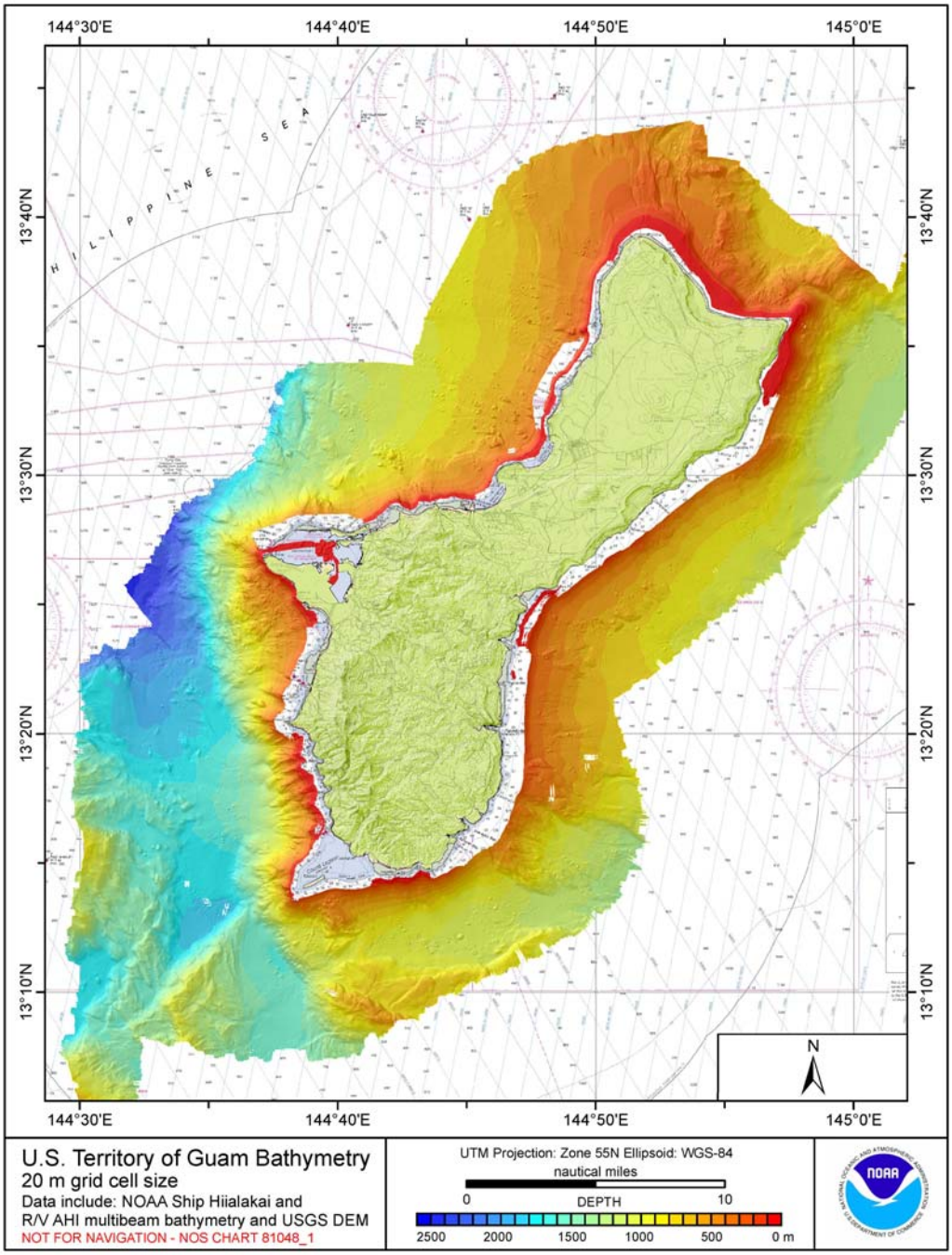

Figure B.1-1: Multibeam bathymetry of Guam shown with a USGS DEM and a NOS nautical chart.

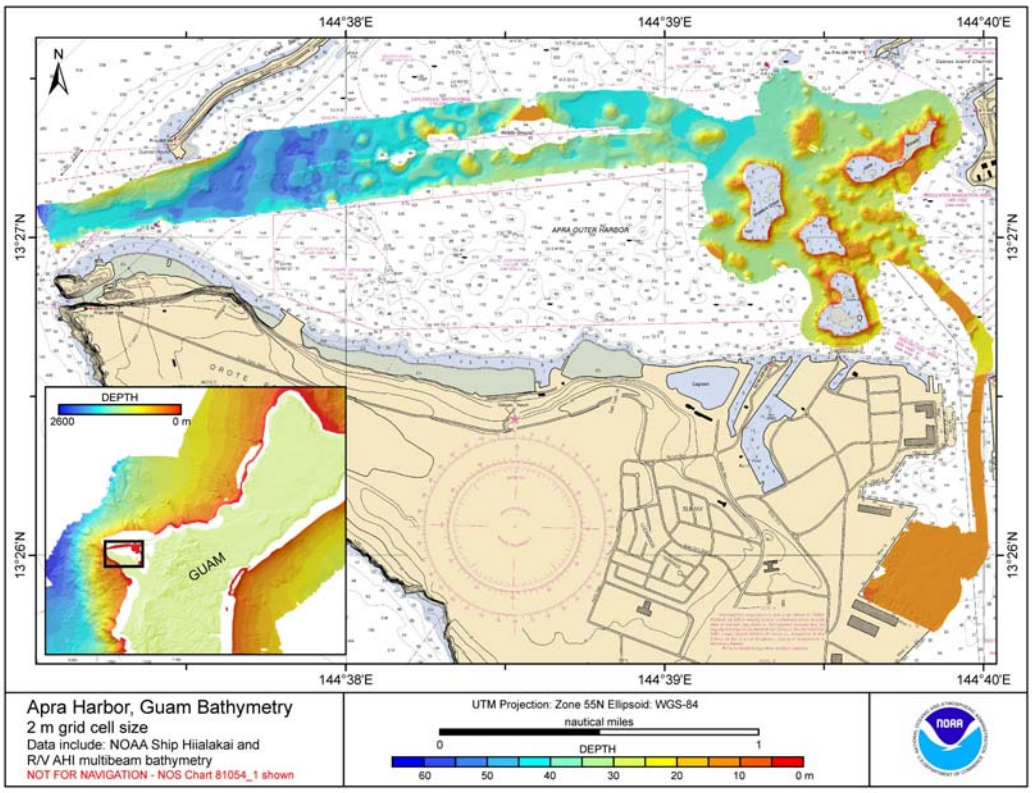

Figure B.1-2: Preliminary multibeam bathymetry of Apra Harbor, Guam shown with a NOS nautical chart. Inset shows the deeper water bathymetry and the location of the larger map.

B.2. Oceanography and Water Quality

In total, four instruments were recovered and six instruments were deployed at Guam during HI-07-02. One sea surface temperature (SST) buoy and SST buoy anchor were removed and a new SST buoy and anchor were deployed in the same location. Three subsurface temperature recorders (STR) were recovered and replaced: one colocated with REA 9 on the north side of the island, one at the southern end of the island co-located with REA 3, and one attached to the SST anchor. An Ecological Acoustic Recorder (EAR) with attached STR was deployed on the northern end of Guam proximate to REA 7. (Fig. B.1-1)

Forty-five shallow water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Guam at approximately 2-mile intervals following the 30 m contour. At 13 of these CTD locations, water sample profiles were performed concurrently, using a daisy chain of Niskin bottles at 1 m, 10 m, 20 m and 30 m depths, for a total of 110 discrete water samples measuring chlorophyll and nutrient concentrations.

In situ SST data obtained from October 2005 to May 2007 shows seasonal variability with warm temperatures observed from July to November and cooler temperatures from January to April (Fig. B.1-2). A particularly warm event occurred in September to October 2006 when SST was ~1.0 °C above the climatological mean, reaching a maximum of 30.6 °C. This event was also observed via Satellite; however, in situ data shows temperatures surpassing the bleaching threshold by 0.3 °C for approximately a week, while remotely sensed data briefly reaches it. Both in situ SST and Satellite data are 0.5 °C warmer than the climatological average from November 2005 to July 2006, and except for the previously discussed warm period in 2006, both data sets follow the climatology rather closely for the remainder of the time series.

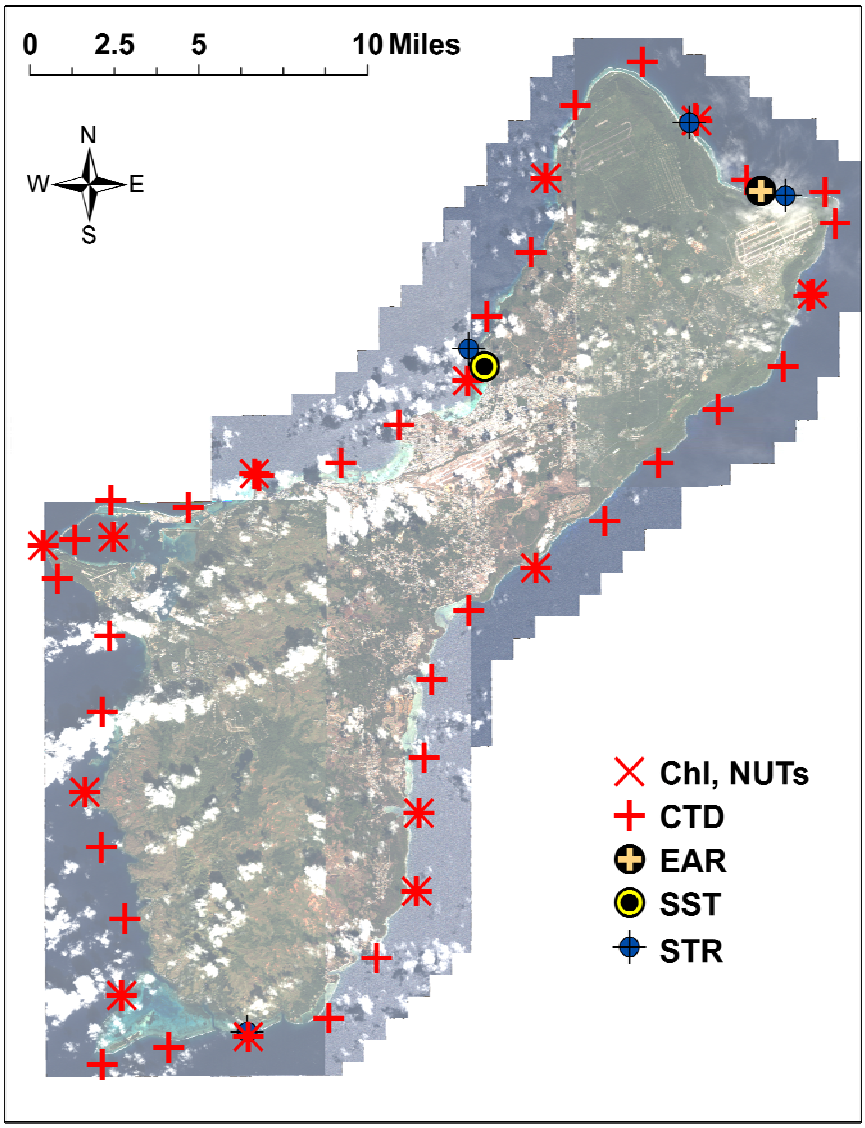

Figure B.2-1. Positions of CTDs, water samples and moorings at Guam.

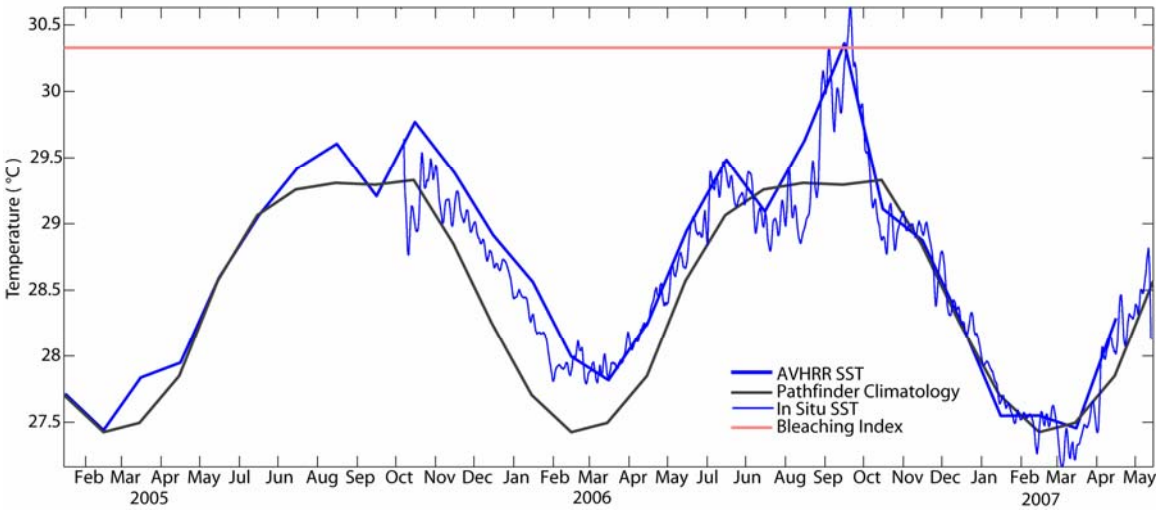

Figure B.2-2: In situ sea surface temperature time series from Guam overlaid with AVHRR (Advanced Very High Resolution Radiometer) monthly sea surface temperature and Pathfinder SST climatology, and including the coral reef bleaching index.

B.3 Rapid Ecological Assessment (REA) Site Descriptions

REA surveys were conducted at 10 sites at Guam (Table B.3-1). Locations of all REA sites around Guam are shown in Figure B.3-1. The descriptions of each site are listed in the order they were occupied by the REA team.

Table B.3-1. Sites surveyed by REA team, HI-07-02, May 2007. Depths and temperature are from Kenyon's dive gauge.

Site #	Date	Latitude (north)		Longitude (east)		Transect depth range, m	Max. depth, m	Temp, °C
GUA-01	5/12/07	13	25.822	144	38.251	10.3-15.2	16.7	28.3
GUA-10	5/12/07	13	28.414	144	41.593	11.8-13.3	14.5	28.9
GUA-09	5/13/07	13	37.965	144	53.572	10.3-12.1	16.7	28.9
GUA-05	5/13/07	13	34.739	144	49.684	12.1-13.6	17.3	28.9
GUA-04	5/13/07	13	31.016	144	47.845	13.9	15.2	28.9
GUA-07	5/14/07	13	36.154	144	55.603	13.6-18.2	19.1	28.9
GUA-08	5/14/07	13	29.328	144	52.648	10.3-13.6	13.6	28.9
GUA-11	5/15/07	13	25.697	144	48.608	10-15.2	15.2	28.9
GUA-03	5/15/07	13	14.508	144	42.174	9.3-11.8	11.8	28.9
GUA-02	5/15/07	13	18.300	144	39.174	10.3-14.8	14.8	28.9

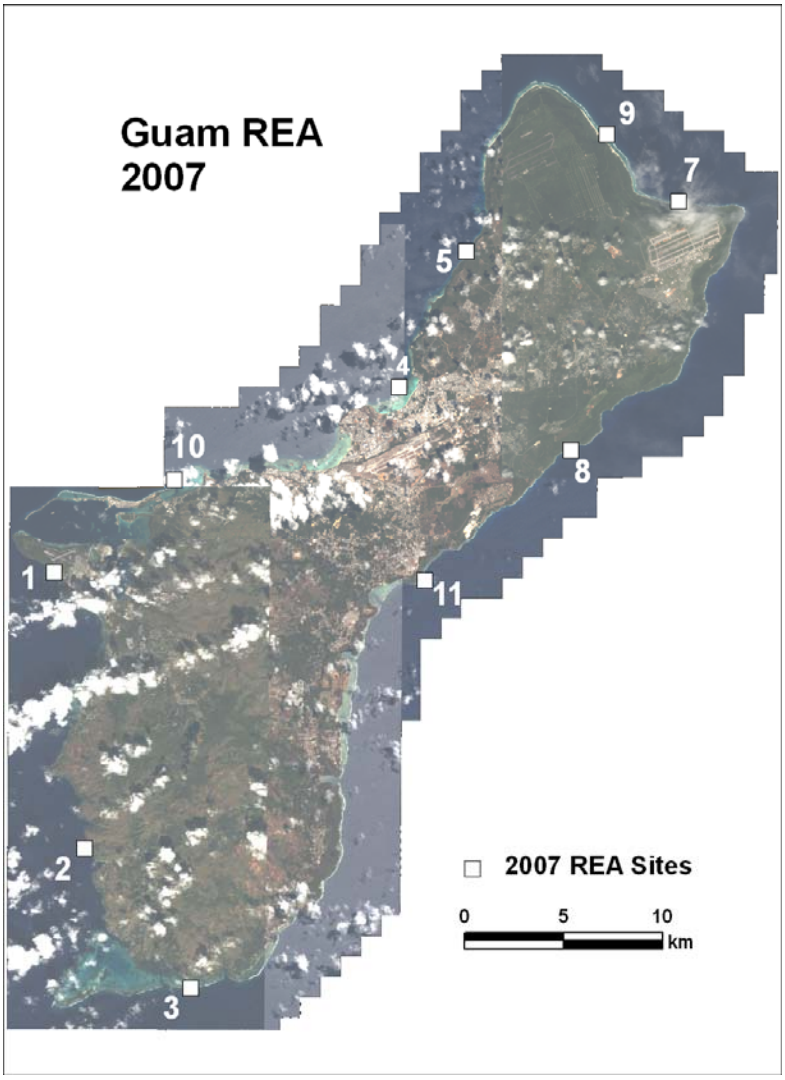

Figure B.3-1. Location of 2007 REA survey sites at Guam.

GUA-1
May 12, 2007

Southern coast, Orote Peninsula, outside Apra Harbor, transect depth 34–50 ft. Inside Orote Peninsula Ecological Reserve Area established by the U.S. Navy. Located just off of the Orote Landfill seawall and was the site of military dumping after World War II. Materials dumped in the area included PCBs. Low topographic relief. Fourteen genera of scleractinian corals enumerated within 50 m^2. No additional genera seen outside of the belt transects. *Leptastrea*, *Porites*, and *Montipora* most numerically abundant, but low coral cover (visual estimate <1%). Coral growth form mainly small nodular or encrusting colonies. Low percent live coral cover (5.9%) dominated by small colonies of *Montipora* spp. and *Leptastrea* sp. Turf-algae comprised over 70% of benthic cover. Coral disease surveys reported one case of tissue loss/white syndrome on *Porites* cf. *lobata*, seven cases of mild-focal bleaching on *Montipora* and *Porites*, and four cases of discolorations

and algal-related irritations on *Porites* and *Montipora.* Algae survey reported a few main macroalgal species such as *Padina boergesenii* (including vaughniella stage) and *Halimeda* spp. Other species collected included *Amphiroa fragilissima, Galaxaura cohaerens,* and an unknown red alga. There were also several cyanobacteria species blooming in the area forming mats covering much of the site.

GUA-10
May 12, 2007
Piti Bay, transect depth 39–44 ft. Located within Piti Bomb Holes Marine Preserve. Limited fishing for seasonal fish (juvenile rabbitfish and *Selar crumenopthalmus*) is permitted in this preserve; all other marine life is protected (enforced since 2001). Sixteen genera of scleractinian corals, 1 octocoral genus (*Sinularia*?) enumerated within 50 m^2. Three additional genera (*Oulophyllia, Stylocoeniella, Lobophytum*) seen outside belt transects. Unspecified octocoral species abundant. *Porites* and unspecified octocoral species numerically abundant. Moderately low percent live coral cover (15.7%) dominated by *Porites* spp. (>87%). Turf-algae comprised over 49% of benthic cover and macroalgae accounted for nearly 20%. Coral disease surveys reported one case of mild, focal bleaching on *Porites*, six cases of *Porites* pink irritations. Additionally five cases of coralline algal lethal disease (CLOD) were enumerated. Algae surveys reported that *Halimeda* spp. (*H. discoidea, H. opuntia, H. cuneata*) and crustose coralline algae (CCA) were very abundant along the transects. Other species collected on the transect included: *Crouania minutissima, Dictyota ceylanica, Neomeris van-bosseae, Portieria* sp., *Tolypiocladia* sp., *Neomeris* sp. and *Dictyosphaeria cavernosa*. Species collected randomly included one unknown green alga.

GUA-9
May 13, 2007
Jinapson, north side, transect depth 34–40 ft. Adjacent to Andersen Air Force Base. The site has low accessibility due to strong currents and rough seas. There are no rivers in this area. High coral diversity site: 18 genera of scleractinian corals, 3 octocoral genera, and 2 hydrozoan genera (*Millepora, Heliopora*) enumerated within 50 m^2. No additional genera seen outside belt transects. Strong surge made coral census difficult. No single coral genus dominated the site. Low percent live coral cover (17%). Turf-algae comprised over 65% of benthic cover. Disease surveys reported two cases of bleaching and discoloration in *Astreopora*, one case of white syndrome/tissue loss on *Goniastrea*, six cases of pink irritations on *Porites*, three cases of *Porites* discoloration and irritations, and one case of coralline algal lethal disease. Algae surveys showed that *Halimeda* spp. and *Portieria harveyi* were common. Other species found in the transects were *Neomeris* spp., *Padina borgeseneii*, *Turbinaria ornate*. A more diverse algal community was located in the crevasse areas, including: *Amphiroa fragillisima, Caulerpa taxifolia, Avrainvaillia erecta, Boergesenia forbeseii,* and *Tricleocarpa fragilis*.

GUA-5
May 13, 2007
Haputo; small arms firing range, northwest side, transect depth 40–45 ft. Located within Haputo Ecological Reserve Area established by U.S. Navy, downstream from the

Tanguisson WWTP and has experienced repeated outbreaks of *Acanthaster planci*. Fifteen genera of scleractinian corals and 3 octocoral genera enumerated within 50 m^2. No additional genera were seen outside belt transects. Site numerically dominated by *Porites*, most of which had degraded appearance. Moderately low percent live coral cover (15%); dominated by *Porites* spp. Turf-algae comprised over 58% of benthic cover and macroalgae accounted for nearly 10%. Coral disease surveys reported two cases of mild focal bleaching on *Porites*, numerous cases (12) involving tissue loss lesions with discolored irritations and algal overgrowth on *Porites*, and 1 case of *Porites* pink irritations. Additionally two cases of COTS predation on *Porites* and one case of *Porites* cyanobacterial overgrowth were enumerated. Algae surveys reported a common occurrence of *Dictyosphaeria* and *Valonia fastigiata* in the transect area, although blue-green algae covered most of the area. Other species found within the transect area were *Amphiroa fragillisima, Neomeris* spp. Species found during random swims included *Ventricaria ventricosa*, *Halimeda opuntia*, *Halimeda* spp., and *Peyssonnelia* spp.

GUA-4
May 13, 2007
Tumon Bay, transect depth 46 ft. Located within Tumon Bay Marine Preserve, established in 2001. Limited fishing activity is permitted in this preserve. Adjacent to heavily developed tourist district, and reef flat is impacted by high levels of recreational use and drainage from Tumon area. Fifteen genera of scleractinian corals and 1 octocoral genus enumerated within 50 m^2. Two additional scleractinian genera (*Cycloseris, Diploastrea*), one octocoral genus (*Lobophytum*), and one hydrozoan genus (*Heliopora*) seen outside belt transects. Site dominated by *Porites rus* and the brown alga *Padina*. Moderately low percent live coral cover (15%); dominated by *Porites* spp. Macroalgae (mainly *Padina*) comprised 45% of benthic cover and turf-algae amounted to 31%. Coral disease surveys reported 2 cases of *Porites* pink irritations and 11 cases of COTS predation on *Porites*, *Goinastrea*, and *Galaxea*. Additionally, eight cases of coralline algal lethal disease (CLOD) were detected. Algae surveys reported that *Padina borgeseneii* was the dominant species at this site, but a couple of cryptic *Caulerpa* species were discovered. There was a brown cyanobacteria film covering most of the substrate. *Tydemania expeditionis* and two *Caulerpa* spp. were collected during the random swim.

GUA-7
May 14, 2007
North side, transect depth 45–60 ft. Located within the Pati Point Marine Preserve. Fishing is limited to hook-and-line method from shore. Preserve established by the Government of Guam in 2001. Access difficult due to currents and seas. No rivers are located near this site. Fifteen genera of scleractinian corals, two octocoral genera, and one hydrozoan genus enumerated within 50 m^2. No additional genera seen outside belt transects. Site numerically dominated by helmet-shaped *Porites*, with 12 large (>40 cm maximum diameter) colonies within transect belts. Several *Pocillopora woodjonesi* colonies were in the area, one of which was more than one meter in diameter. Moderate percent live coral cover (23.5%), dominated by *Porites* spp. (83%). Turf-algae comprised over 46% of benthic cover and macroalgae 20%. Disease surveys reported nine cases of

Porites pink irritations, one case of *Porites* white syndrome/tissue loss, and four cases of coralline lethal orange disease. Algae surveys reported that *Halimeda* spp. were very common at this site and there was an unidentified species (*Rhipiliopsis* spp. or *Avrainvaillea* spp.) observed regularly on the transects. The gradual reef slope had a few nooks and crannies around the transect area. *Jania capillacea, Neomeris* sp., *Tolypocladia calodictyon, Turbinaria* sp. and *Avrainvaillea lacerata* were collected within the transect area. *Gibsmithia hawaiiensis, Dictyota cerymia,* and *Halimeda minima* were collected during the random swim.

GUA-8
May 14, 2007

Northeast, transect depth 34–42 ft. Located near Champanaya Point. Access is difficult due to distance from available launching points. Development in this area is low, and there are no rivers. A large golf course lies to the south of this area. Fifteen genera of scleractinian corals, one octocoral genera, and one hydrozoan genus enumerated within 50 m^2. No additional genera seen outside belt transects. High diversity and abundance of *Acropora*. Moderately high percent live coral cover (39%) dominated by *Montipora* spp. (50%) and *Porites* spp (12.5%). Turf-algae comprised over 55% of benthic cover and macroalgae accounted for nearly 2%. Disease surveys reported six cases of bleaching and discolorations on *Astreopora* and *Platygyra*, one case of tissue loss/white syndrome on *Montipora*, one case of skeletal growth anomaly on *Montipora*, and five cases of COTS predation on *Porites*, *Cyphastrea*, *Goniastrea*, *Montipora*, and *Astreopora*, respectively. The algae survey team collected no novel species within the transect area but collected nice specimens during the random swim: *Peyssonnelia namoena, Caulerpa racemosa* var. *lamourouxii, Caulerpa geminata, Bryopsis pennata,* and an unidentified red alga found under a ledge (possibly *Wranglia* spp.).

GUA-11
May 15, 2007

East side, north of University of Guam Marine Lab, transect depth 33–40 ft. Part of this site was impacted by a strong earthquake in 1997 that sheared off part of the adjacent cliffs. In 2005, the transects went north through this area. In 2007, the transects were laid to the south and covered an area that had higher rugosity and more coral cover. Fifteen genera of scleractinian corals, 2 octocoral genera enumerated within 50 m^2. One additional genus (*Hydnophora*) seen outside belt transects. Heavy algal cover (*Caulerpa* and turf-algae). Relatively low percent live coral cover (11.8%). Turf-algae and fleshy macroalgae comprised over 80% of benthic cover. Disease surveys reported three cases of bleaching and discolorations on *Astreopora* spp. and six cases of COTS predation on *Astreopora, Porites*, and *Montipora*. Algae surveys reported the following species, observed within the transect area : *Codium bulbopilum, Galaxaura* spp., *Portieria hornemannii, Halimeda* spp., *Amphiroa* spp., *Caulerpa* spp., *Jania capillacea, Gelidiella acerosa, Gelidiella pannosa, Boodlea composita, Botryocladia tenuissima,* and *Liagora* spp. *Caulerpa biserrulata* and *Dictyosphaeria* spp. (probably *D. cavernosa*).

GUA-3
May 15, 2007
South point of Guam, just east of Cocos Lagoon, transect depth 31–33 ft. Located within Achang Reef Flat Marine Preserve. Limited fish for seasonal fish (juvenile rabbitfish, *Selar crumenopthalmus*, and juvenile fusiliers) is allowed by special permit during certain times of the year (enforced since 2001). A number of rivers drain into this preserve and there are extensive badlands within these watersheds. Sixteen genera of scleractinian corals, 3 octocoral genera (including *Stereonephthya*, rare) enumerated within 50 m^2. Four additional genera (*Heliopora, Scapophyllia, Acanthastrea, Goniopora*) seen outside belt transects. Low percent live coral cover (11.8%). Turf-algae and fleshy macroalgae comprised over 80% of benthic cover. Disease surveys reported nine cases of bleaching and discolorations on *Astreopora* and three cases of COTS predation on *Porites* and *Montipora*. Algae surveys reported that this community was predominantly composed of *Padina boergesenii* with turf mats made up of *Tolypocladia calodictyon*, *Jania capillacea*, *Amphiroa* spp., blue-green algae, and vaughniella stage of *P. borgesenii*. Other species found within the transect area included *Dictyota bartayresiana, Caulerpa* spp., *Avrainvaillea lacerata, Asparagopsis taxiformis, Lobophora variegata, Turbinaria ornata*, and *Hydroclathrus clathrata*. *Halymenia dilatata*, and *Croania* sp. were found and collected during the random swim.

GUA-2
May 15, 2007
Southeast side, Fouha Bay, transect depth 34–46 ft. A number of researchers have documented substantial sedimentation impacts at this site. The watershed above Fouha Bay is prone to wildfires set by hunters, which has led to large badland areas and high levels of erosion from the watershed's steep slopes. Attempts to reforest the area have been unsuccessful due to continued burning, but a new effort is underway. Unusually high cnidarian diversity: 20 genera of scleractinian corals enumerated within 50 m^2. Eight additional genera (*Acropora, Platygyra, Fungia, Plesiastrea, Hydnophora, Echinopora, Echinophyllia, Sarcophyton*) seen outside belt transects. Heavy cover *Padina* algae. Low percent live coral cover (4.8%). Turf-algae and *Padina* comprised nearly 80% of benthic cover. Disease surveys reported three cases of bleaching on *Montipora, Porites* and *Goniastrea*, two cases of discolorations and algal overgrowth on *Porites*, and two cases of COTS predation on *Astreopora*. Algae surveys reported that *Padina borgesenii* was the prevalent species at this site. *Halimeda* spp., *Amphiroa* spp. and *Galaxaura* spp. were also common. Also recorded on this sloping reef were *Gelidiella pannosa, Avrainvaillea lacerata, Dictyota bartayresiana, Dictyosphaeria cavernosa*, and *Neomeris* spp.

B.4. Benthic Environment

B.4.1. Algae

Tentatively for Guam and the southern CNMI, 45 macroalgae genera were found altogether: 37 known species (16 genera) of green algae (Chlorophyceae), 28 known species (25 genera) of red algae (Rhodophyceae), and 6 known species (4 genera) of

brown algae (Phaeophyceae). Also, several unidentified species of filamentous algae were grouped into the functional category of turf algae and multiple species of cyanobacteria were found. Turf and calcified algae seem to do well on these wave-scoured islands. Subsequent to microscopic examination of samples, it is expected that identification of epiphytes and several species of macroalgae the number of species collected will increase substantially. Quantitative sites were all situated in depths of about 35-55 ft., mostly around 40 ft. A comprehensive algae list is shown below in Table B.4-1. Further examination of species is needed to increase accuracy and complete the list.

Table B.4-1. List of putative algae species in the southern Mariana Islands: Guam, Rota, Aguijan, Tinian, and Saipan.

Green algae	**Red algae**
Avrainvaillea erecta	*Amphiroa fragillissima*
Avrainvaillea lacerate	*Actinotrichia* sp.
Boergesenia forbesii	*Asparagopsis taxiformis*
Boodlea vanbosseae	*Botryocladia skottsbergii*
Bornetella oligospora	*Botryocladia tenuissima*
Bryopsis pennata	*Crouania* sp.
Caulerpa biserrulata	*Dichotomaria marginata*
Caulerpa cupressoides	*Galaxaura cohaerens*
Caulerpa elongata	*Gelidiella acerosa*
Caulerpa filicoides var. *andamanensis*	*Gelidiella pannosa*
Caulerpa geminata	*Gelidiopsis* sp.
Caulerpa nummularia	*Gibsmithia dotyi*
Caulerpa spp.	*Gibsmithia hawaiiensis*
Caulerpa racemosa var. *lamourouxii*	*Halymenia dilatata*
Caulerpa sertularioides	*Haloplegma duperreyi*
Caulerpa serrulata	*Jania capillacea*
Caulerpa taxifolia	*Liagora* sp.
Caulerpa webbiana	*Lobophora variegata*
Chlorodesmis hildebrandtii	*Mastophora rosea*
Codium bulbopilum	*Mesophyllum funagutiense*
Dictyosphaeria cavernosa	*Neurymenia fraxinifolia*
Dictyosphaeria versluysii	*Peyssonnelia inamoena*
Halimeda cuneata	*Platoma* cf. *ardreanum*
Halimeda cf. *discoidea*	*Portieria harveyi*
Halimeda lacunalis f. lata	*Portieria hornemannii*
Halimeda macroloba	*Predaea weldii*
Halimeda macrophysa	*Tolypocladia calodictyon*
Halimeda minima	*Tricleocarpa fragilis*

Green algae	**Red algae**
Halimeda opuntia	UNK SP. 1
Halimeda spp.	UNK SP. 2
Microdictyon setchellianum	UNK SP. 3 (UNK Sp. 2)
Neomeris van-bosseae	UNK SP. 4-red epiphyte
Neomeris spp.	**Brown algae**
Rhipiliopsis sp.	*Dictyota ceylanica*
Tydemania expeditionis	*Dictyota bartayresiana*
Valonia fastigiata	*Hydroclathrus clathrata*
Ventricaria ventricosa	*Padina boergesenii*
Unk. Species	*Turbinaria conoides*
Green mat/fuzz (Unk sp. 1)	*Turbinaria ornate*
Functional groups	
Blue-green	
Turf	
CCA	

Quantitative algal surveys were conducted at 10 sites outside Guam. All sites were previously surveyed in 2003 or 2005 and were forereef habitats within 150 m of shore or the northwestern reef flat. Time constraints prevented resurvey of the 2003 site GUA-06 on the east/windward side of the island.

Guam, in most areas, is surrounded by a fringing reef and has a variable number of reef classifications including but not limited to patch reefs, reef slopes spur-and-groove systems. Several sites around the island had strong surge. Twenty-four green algae species (Chlorophyta), 21 red algae species (Rhodophyta), and 5 brown algae species (Phaeophyta) were counted. Some communities showed monotypic dominance while others were very diverse. The most conspicuous macroalgae at most sites were *Halimeda* spp., and *Padina* spp. Turfs and blue-green algae dominated most sites, and crustose coralline algae were also present. Table B.4-2 lists relative abundance of algae species in Guam.

Table B.4-2: Algal taxa or functional groups recorded in photoquadrats by site at Guam. First row of numbers indicates the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat.

	GUA-01	GUA-10	GUA-09	GUA-05	GUA-04	GUA-07	GUA-08	GUA-11	GUA-03	GUA-02
GREEN ALGAE										
Avrainvaillea erecta	0	0	8.3	0	0	0	0	0	0	0
	0	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Avrainvaillea lacerata	0	0	0	0	0	0	0	0	50	8.3
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4.5**	**5.5**
Boergesenia forbesii	0	0	8.3	0	0	0	0	0	0	0
	0	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Boodlea vanbosseae	0	0	0	0	0	0	0	25	0	8.3
	0	**0**	**0**	**0**	**0**	**0**	**0**	**7.7**	**0**	**3**
Caulerpa biserrulata	0	0	0	0	0	0	0	8.3	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**
Caulerpa cupressoides	0	0	0	0	0	0	0	0	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Caulerpa geminata	0	0	0	0	0	0	0	8.3	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**
Caulerpa nummularia	0	0	0	0	0	0	0	0	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Caulerpa spp.	0	0	0	0	8.3	0	0	8.3	0	0
	0	**0**	**0**	**0**	**6**	**0**	**0**	**6**	**0**	**0**
Caulerpa taxifolia	0	0	8.3	0	0	0	0	0	0	0
	0	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Codium bulbopilum	0	0	0	0	0	0	0	41.7	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**2.3**	**0**	**0**
Dictyosphaeria cavernosa	0	0	0	0	0	0	0	0	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Dictyosphaeria versluysii	0	16.7	8.3	50	0	0	0	0	33.3	16.7
	0	**4.5**	**5**	**3.3**	**0**	**0**	**0**	**0**	**5.5**	**6**
Halimeda cuneata	0	8.3	0	0	0	0	0	0	0	0
	0	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Halimeda cf.	0	8.3	0	0	0	0	0	0	0	0

	GUA-01	GUA-10	GUA-09	GUA-05	GUA-04	GUA-07	GUA-08	GUA-11	GUA-03	GUA-02
discoidea	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Halimeda opuntia	0	8.3	8.3	0	0	8.3	8.3	0	0	0
	0	**1**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**0**
Halimeda spp.	75	75	66.7	75	83.3	75	75	83.3	50	91.7
	2.8	**1.7**	**1.2**	**2.5**	**2.7**	**1.6**	**1.8**	**5.4**	**3.3**	**3.8**
Neomeris van-bosseae	8.3	8.3	0	0	0	0	0	0	0	0
	7	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Neomeris spp.	0	8.3	16.7	33.3	25	16.7	33.3	0	16.7	16.7
	0	**6**	**3.5**	**5.5**	**4.7**	**5.3**	**3.4**	**0**	**5**	**5.5**
Rhipiliopsis sp.	0	0	0	0	0	75	0	0	0	0
	0	**0**	**0**	**0**	**0**	**2.6**	**0**	**0**	**0**	**0**
Tydemania expeditionis	0	0	0	0	0	0	0	0	8.3	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**
Valonia fastigiata	0	0	0	33.3	0	8.3	0	0	0	0
	0	**0**	**0**	**2.4**	**0**	**4**	**0**	**0**	**0**	**0**
RED ALGAE										
Amphiroa fragillissima	33.3	0	8.3	41.7	8.3	16.7	0	66.7	50	58.3
	4	**0**	**2**	**3.4**	**6**	**4.5**	**0**	**5.1**	**4**	**3.5**
Actinotrichia sp.	8.3	0	0	0	0	0	0	0	0	0
	6	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Asparagopsis taxiformis	0	0	0	0	0	0	0	0	50	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4.5**	**0**
Botryocladia skottsbergii	8.3	8.3	0	0	0	0	0	0	0	0
	5	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Botryocladia tenuissima	0	0	0	0	0	0	0	8.3	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**0**	**0**
Crouania sp.	0	8.3	0	0	0	0	0	0	0	0
	0	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Galaxaura cohaerens	33.3	0	0	0	0	0	0	50	16.7	25
	3.5	**0**	**0**	**0**	**0**	**0**	**0**	**4.1**	**4.3**	**3.3**
Gelidiella acerosa	0	0	0	0	0	0	0	25	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**5.3**	**0**	**0**
Gelidiella pannosa	0	8.3	0	0	8.3	0	0	33.3	41.7	25
	0	**5**	**0**	**0**	**4**	**0**	**0**	**4.8**	**4.6**	**5.7**

	GUA-01	GUA-10	GUA-09	GUA-05	GUA-04	GUA-07	GUA-08	GUA-11	GUA-03	GUA-02
Jania capillacea	0	8.3	0	0	0	16.7	0	16.7	0	0
	0	**5**	**0**	**2**	**0**	**5**	**0**	**3.5**	**0**	**0**
Liagora sp.	0	0	0	0	0	0	0	8.3	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**0**	**0**
Lobophora variegata	0	0	0	0	0	0	0	0	8.3	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**
Mastophora rosea	0	0	0	0	0	0	0	0	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**0**	**0**
Peyssonnelia inamoena	0	0	0	0	0	0	0	0	8.3	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**
Portieria harveyi	0	8.3	0	0	0	0	0	0	0	0
	0	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Portieria hornemannii	0	0	33.3	16.7	0	0	0	50	0	0
	0	**0**	**3.3**	**2.5**	**0**	**0**	**0**	**4.9**	**0**	**0**
Tolypocladia calodictyon	0	8.3	0	0	0	8.3	0	0	16.7	0
	0	**4**	**0**	**0**	**0**	**3**	**0**	**0**	**4**	**0**
Tricleocarpa fragilis	0	0	8.3	0	0	0	0	0	0	0
	0	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
UNK SP. 3 (maybe same as UNK Sp. 2)	0	0	0	0	0	0	0	8.3	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**
BROWN ALGAE										
Dictyota ceylanica	8.3	8.3	0	0	0	25	0	0	8.3	16.7
	4	**3**	**0**	**0**	**0**	**2.7**	**0**	**0**	**4**	**6**
Dictyota bartayresiana	0	0	0	0	0	0	0	8.3	16.7	8.3
	0	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**4**	**7**
Hydroclathrus clathrata	0	0	0	0	0	0	0	0	8.3	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**
Padina boergesenii	83.3	8.3	33.3	0	83.3	8.3	0	0	91.7	91.7
	2.5	**4**	**3.3**	**0**	**1.4**	**5**	**0**	**0**	**1**	**1**
Turbinaria ornata	0	0	16.7	0	0	25	0	0	25	0
	0	**0**	**3.5**	**0**	**0**	**5.7**	**0**	**0**	**6**	**0**
FUNCTIONAL GROUPS										
Blue-green	58.3	66.7	33.3	58.3	75	50	91.7	91.7	8.3	41.7

	GUA-01	GUA-10	GUA-09	GUA-05	GUA-04	GUA-07	GUA-08	GUA-11	GUA-03	GUA-02
	3.9	**2.1**	**2.5**	**1**	**2.3**	**4**	**1.3**	**1.8**	**6**	**3.2**
turf	75	41.7	58.3	41.7	25	41.7	0	66.7	75	83.3
	1.5	**2.6**	**3**	**3**	**2**	**1.8**	**3**	**3**	**2**	**2.5**
CCA	8.3	33.3	33.3	25	41.7	8.3	0	16.7	0	33.3
	7	**2.5**	**1.4**	**3**	**3.2**	**1**	**0**	**2.5**	**0**	**4.8**

B.4.1.2 Benthic Towed-diver Surveys – Macroalgae

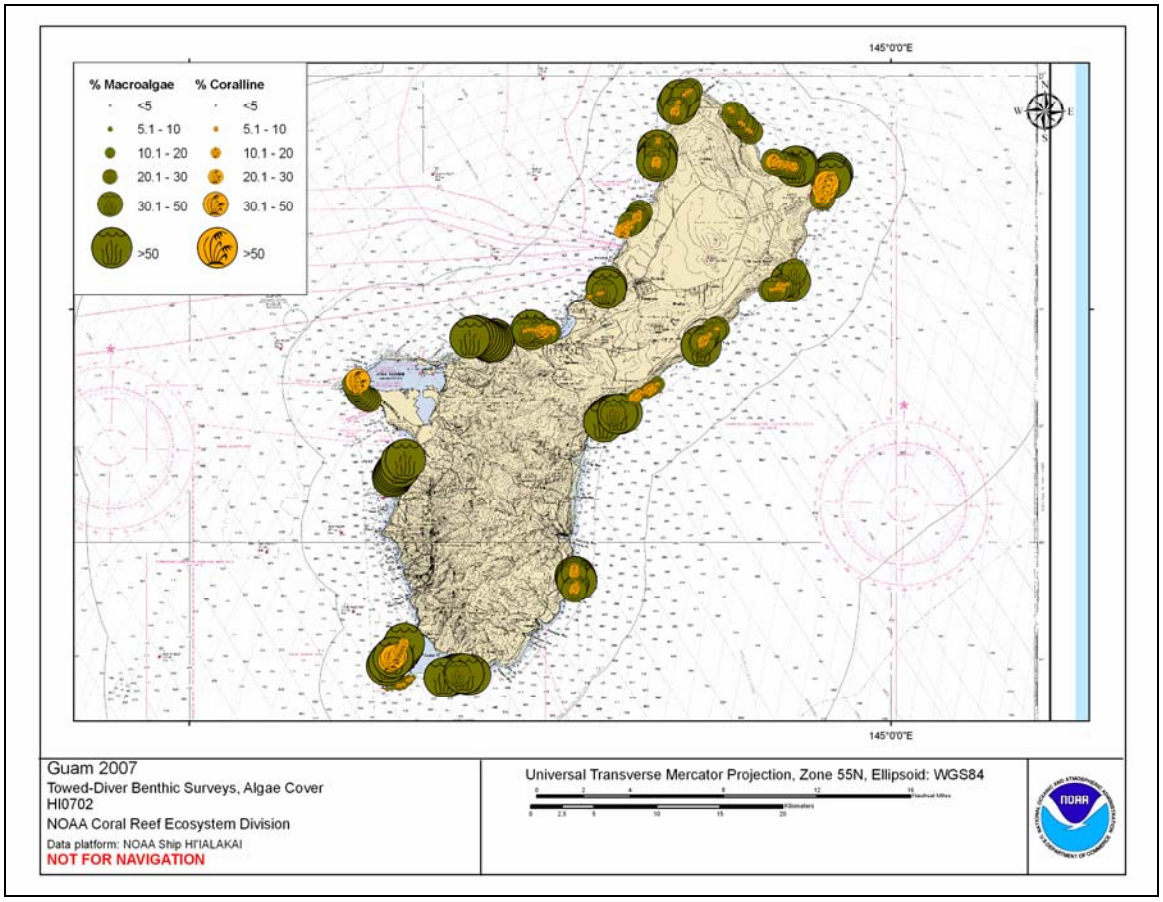

Figure B.4.1.2-1: Macroalgae and coralline algae cover around Guam (2007).

The macroalgae and coralline algae cover around Guam averaged 44% and 8% (range 1.1–100% and 0–50%, respectively). The highest macroalgae cover (average 78%, range 62.5–100%) was located during a towed-diver survey completed around Alutom Island heading north, and ending ~930-meters to the northwest off of Agat. The area was composed of carbonate pavement along a shallow/moderate slope, with *padina* being the dominant macroalgae present. Two additional towed-diver surveys around Togcha Bay

to Talofofo Bay (east side) and Asgadao Island to Babe Island (south) recorded an average of 75% macroalgae cover (40.1–100%). Finally the highest coralline algae cover was located during a towed-diver survey northwest of Cocos Island/Lagoon forereef (average 23%, range 5.1–50%),

B.4.2. Corals

B.4.2.1 Coral Populations

Coral Diversity and Population Parameters

A total of 3,080 cnidarian colonies were enumerated within belt transects covering 500 m^2 at Guam. These represented at least 34 cnidarian genera, of which 27 were scleractinian corals, at least 5 were octocorals (*Sinularia, Lobophytum, Sarcophyton, Cladiella, Stereonephthya,* and uncertain) and 2 were hydrozoans (*Millepora, Heliopora*). The number of colonies enumerated and percentage of coral colonies represented by each taxon are shown in Table B.3.4.2-1. Two additional taxa (*Plesiastrea, Echinophyllia*), not seen in belt transects were observed in the larger area around the transects in at least one site at Guam. Two genera (*Leptastrea* and *Porites*) each contributed more than 10% of the total number of colonies enumerated. Several large (> 1 meter diameter) and spectacular colonies of *Pocillopora woodjonesi* were seen at site GUA-7.

Table B.4.2.1-1. Number of cnidarians surveyed in belt transects at Guam sites in 2007. Taxa contributing more than 10% of the total number of coral colonies are in bold.

Genus	# colonies	% of total
Acanthastrea	16	0.5
Acropora	54	1.8
Astreopora	230	7.5
Cladiella	3	0.1
Cycloseris	2	0.1
Cyphastrea	77	2.5
Diploastrea	5	0.2
Favia	236	7.7
Favites	9	0.3
Fungia	2	0.1
Galaxea	132	4.3
Goniastrea	175	5.7
Goniopora	9	0.3
Heliopora	11	0.4
Hydnophora	2	0.1
Leptastrea	318	**10.3**
Lobophyllia	2	0.1
Lobophytum	17	0.6
Millepora	2	0.1
Montastrea	61	2.0

Genus	# colonies	% of total
Montipora	222	7.2
Other octocoral	125	4.1
Oulophyllia	2	0.1
Pavona	27	0.9
Platygyra	35	1.1
Pocillopora	87	2.8
Porites	1142	**37.1**
Psammocora	41	1.3
Sarcophyton	1	0.0
Scapophyllia	2	0.1
Sinularia	23	0.7
Stereonephthya	4	0.1
Stylocoeniella	4	0.1
Stylophora	2	0.1
Total # colonies	3080	
Area surveyed, m2	500	

Size Class Structure

A size class distribution of all cnidarians enumerated within belt transects at Guam in 2007 are shown in Figure B 4.2.1. Data from 2005, collected by the same scientist, is also presented in the figure for comparison.

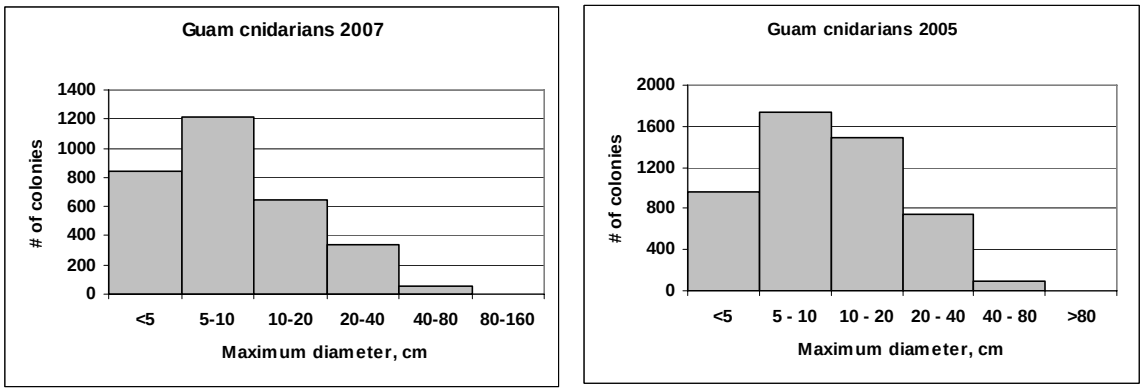

Figure B.4.2.1. Size class distributions of cnidarians enumerated in belt transects at Guam in 2007 and 2005.

B.4.2.2 Percent Benthic Cover

Percent benthic cover surveys at Guam were conducted in concert with the fish, coral population, algae, and invertebrate REA surveys, at 10 different sites selected in 2003 and 2005. The line-intercept methodology quantified a total of 1020 points along 500 m of forereef coral communities at depths ranging between 9 and 14 m. Patterns of intra-island variability in percent benthic cover, derived from the 10 independent REA surveys

in 2007, are reflected in Figure B.3.2.2.1. Point-count surveys indicated that the mean percent live coral cover for all sites combined was relatively low: 16.2 ± 3.1% (mean ± SE). Highest coral cover was recoded at site GUA-8 (39.2%) on the east-facing shore; low percent coral cover (4.9 and 5.9%) was encountered at sites GUA-2 and -1, on the southwest coast and south of Apra Harbor, respectively. Turf-algae and fleshy macroalgae including *Caulerpa* and *Padina* were particularly abundant at most REA sites. A total of 15 scleractinian genera were enumerated along the point-count transects, with *Porites* being the most numerically abundant (45.5 ± 10.9%), followed by *Montipora* (18.8 ± 5.5%), and *Pocillopora* (6.1 ± 1.9%). Figure B.3.2.2.2 illustrates the contribution of the different scleractinain genera to the total percent live coral cover.

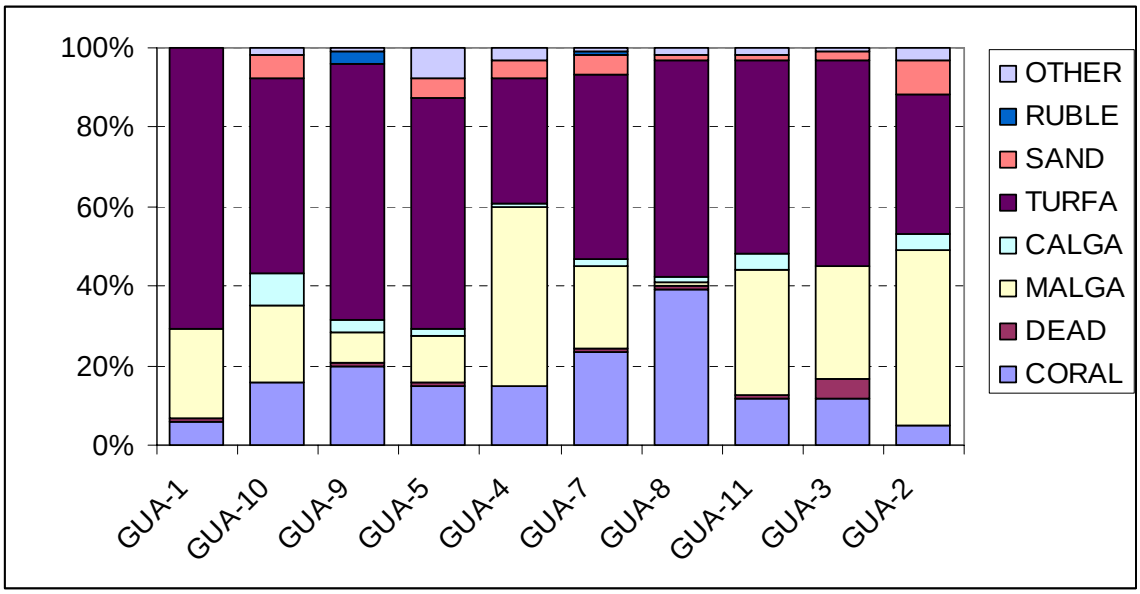

Figure B.4.2.2-1 Mean percent cover of selected benthic elements derived from 10 independent REA surveys at Guam, MAR-RAMP 2007. CORAL: live scleractinian and hydrozoan stony corals; DEAD: dead scleractinian and hydrozoan stony corals (including recent and old dead), MALGA: fleshy macroalgae; CALGA: crustose coralline algae; TURFA: turfalgae-covered carbonate pavement; RUBLE: coral rubble (including recent and old coral rubble covered with turf-algae); SAND: sand; and OTHER: other sessile invertebrates including alcynoarian corals, echinoderms, sponges, tunicates, as well as cyanobacterial mats.

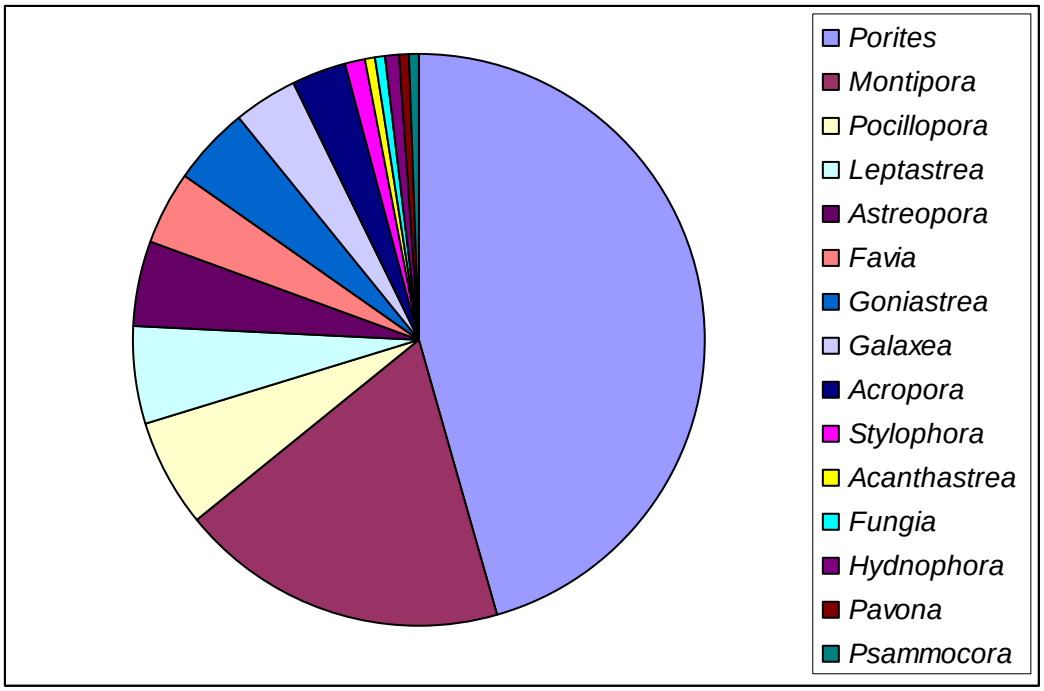

Figure B.4.2.2-2 Percent contribution of the different coral genera to the total live coral cover at Guam, MAR-RAMP 2007.

B.4.2.3 Coral Disease

In 2007, the coral disease that REA surveyed was a total area of ~1,640 m^2 at 10 different sites. A summary of disease occurrence is presented in Table B.4.2.3-1. A total of 85 cases of disease were detected within the total area surveyed. Bleaching and discolorations were the most abundant disease states (49% cases), followed by pigmented irritations (27%) and tissue loss lesions (18.8%). Among sites, GUA-5 on the northwest-facing shore exhibited the greatest occurrence of disease with nearly 20% of cases. Disease conditions, including bleaching and irritations were registered on seven different coral genera, with *Porites* exhibiting over 63% of cases, followed by *Astreopora* (22%) and *Montipora* (9%) (Fig. B.4.2.3-1). Of particular interest, were the percent occurrences of tissue loss and pigmented irritations on *Porites*, bleaching and discolorations on *Astreopora*. In addition, a total of 33 predation scars due to *Acanthaster planci* were enumerated within the total survey area, as well as 18 cases of coralline lethal orange disease.

Table B.4.2.3-1 Cumulative number of cases of disease conditions enumerated at each survey site at Guam during the 2007 RAMP cruise. BLE: bleaching; DIS: discolorations other than bleaching; SGA: skeletal growth anomaly; TLS/WSY: tissue loss/white syndrome. PUS: Porites ulcerative white spot; PIR/IRR: Pink irritations and other coral-algal interactions with pigmentation responses CYA/AOG: cyanobacteial and algal infections. No disease conditions were observed at sites not listed herein. Total survey area ~1,640 m^2.

Disease	**Guam REA Site**										
State	**1**	**11**	**9**	**5**	**4**	**7**	**8**	**11**	**3**	**2**	**Total**
BLE	7	1	2	2			6	3	9	3	33
DIS	4	3								2	9
SGA							1				1
TLS/WSY	1		1	12		1	1				16
PIR/IRR		3	8	1	2	9					23
CYA/AOG				1	1						2
Grand Total	12	7	12	16	3	10	8	3	9	5	85

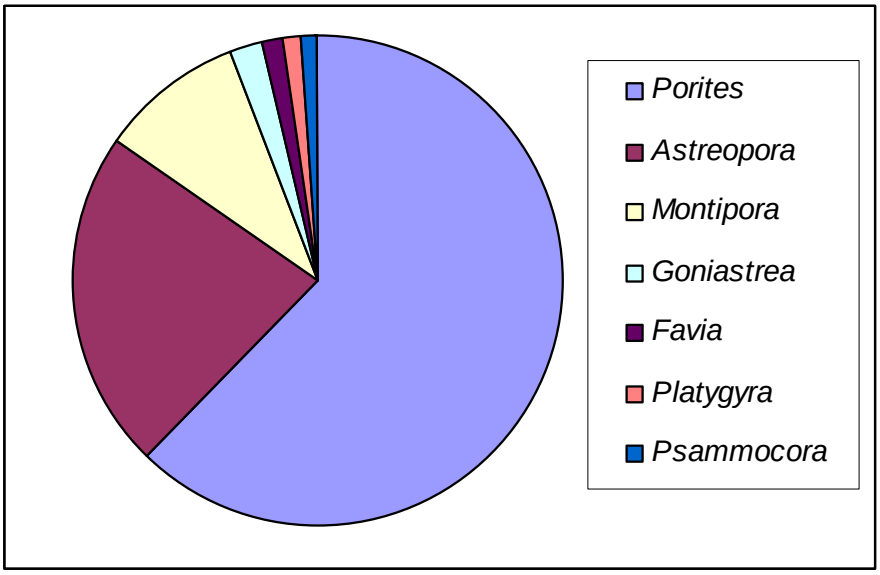

Figure B.4.2.3-1 Percent of cases of disease conditions exhibited by different coral genera.

B.4.2.4 Benthic Towed-diver Surveys – Corals

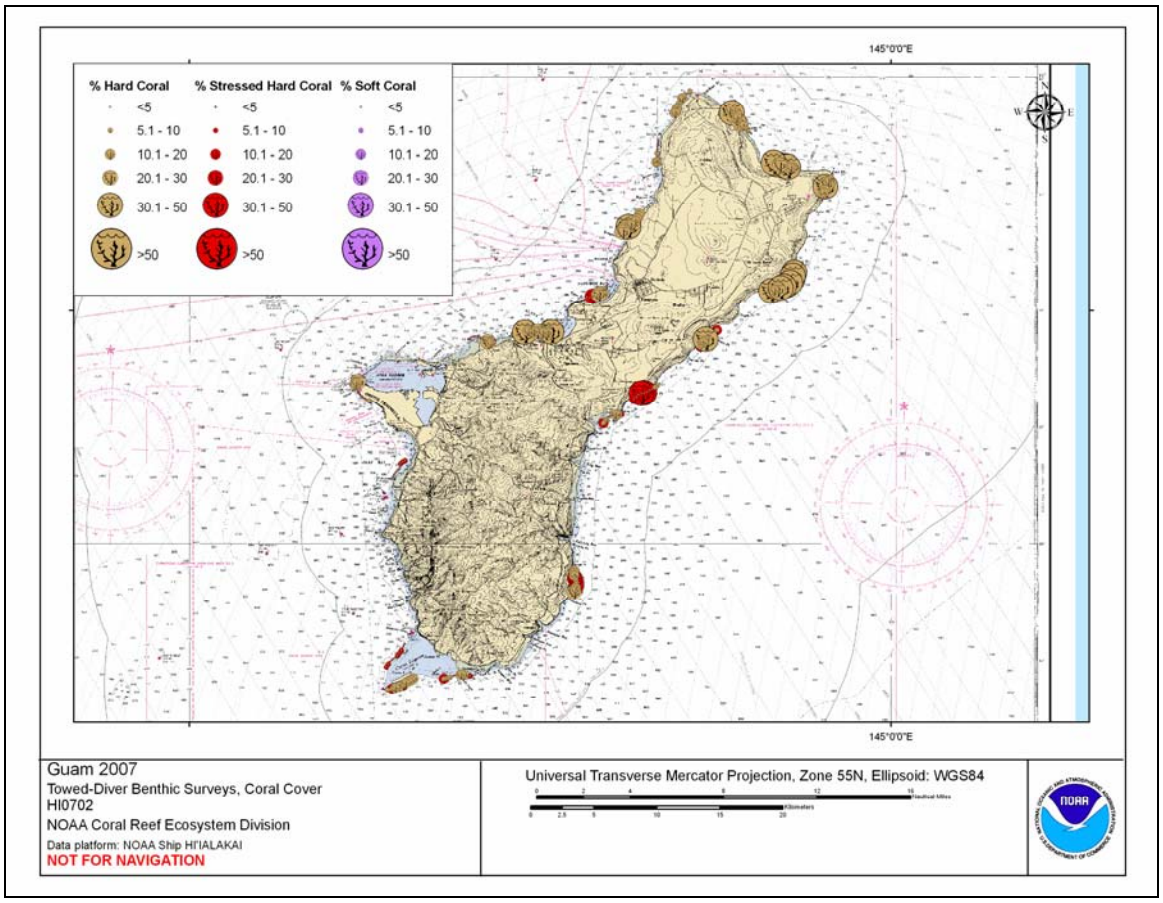

Figure B.4.2.4-1: Hard coral, stressed coral, and soft coral cover around Guam (2007).

The average hard coral cover for Guam was 12% overall (range 0.1–50%), with overall hard coral stress recorded at 5% (range 0–40%). The highest overall hard coral cover was recorded at an average of 35% (range 20.1–50%) during a towed-diver survey of the area approximately 735 meters southwest of Mati Point, ending near Lajuna Point, where low relief encrusting corals dominated many time segments (7/10 segments). Other areas of higher coral cover included a towed-diver survey beginning around 2.5 kilometers west of Pati Point in the north (average 25%, range 1.1 – 50%), and a survey completed from Agana Bay to ~600 meters east of Adelup Point (average 23%, range 20.1–50%). *Porites* species (c.f. *lobata, rus, lichen*), large colonies of *diploastrea heliopora*, and *montiporas* were noted.

The highest overall stressed hard coral was located from Agfayan Point to Aga Point in the southeast corner of Guam (average 20%, range 5.1–30%). The area was characterized as spur-and-groove habitat dominated largely by macroalgae species and an average of 13% overall hard coral cover (range 1.1–20%). Ninety-one COTs were recorded during the survey, suggesting COT predation as a factor for elevated stress levels. Another area of high coral stress was recorded during a towed-diver survey bisecting Fadian Point (average 16%, range 1.1–40%). Overall hard coral cover was

relatively low for the region (average 4%, range 1.1–10%). At N13 29.509, E144 49.549, the towed diver recorded the highest number of COTs during a single time segment in Guam (average 75/5-minute survey), with additional notes indicating high levels of COT predation and coral stress. One hundred eighty-eight COTS were recorded during the entire survey around Fadian Point.

B.4.3 Macroinvertebrates

B.4.3.1 Benthic Towed-diver Surveys - Macroinvertebrates

Macroinvertebrate numbers were relatively low except for three surveys, one around Fadian Point, one around Aga Point, and the other around Pati Point. *Acanthaster planci* (COTs) was abundant on the Fadian and Aga Point surveys. The fewest number of COTs recorded during a 5-minute time segment on the Fadian Point survey was 2, whereas the highest number was 75, for a total of 188 animals. The high presence of this reef predator coincided with high levels of stressed hard corals, suggesting rigorous predation. A total of 91 COTS were observed in the final 10 minutes of survey near Aga Point. This area of spur and groove also exhibited the highest percentage of stressed hard corals, reaching as high as 30%. The average number of sea urchins was generally low, with the exception of the southeast section of the island where an average of 315 sea uchins were recorded every 5 minutes. The overall macroinvertebrate averages per survey for the island of Guam were as follows: 3.42 COTs, 24.2 sea urchins, 8.9 sea cucumbers and 0.1 giant clams.

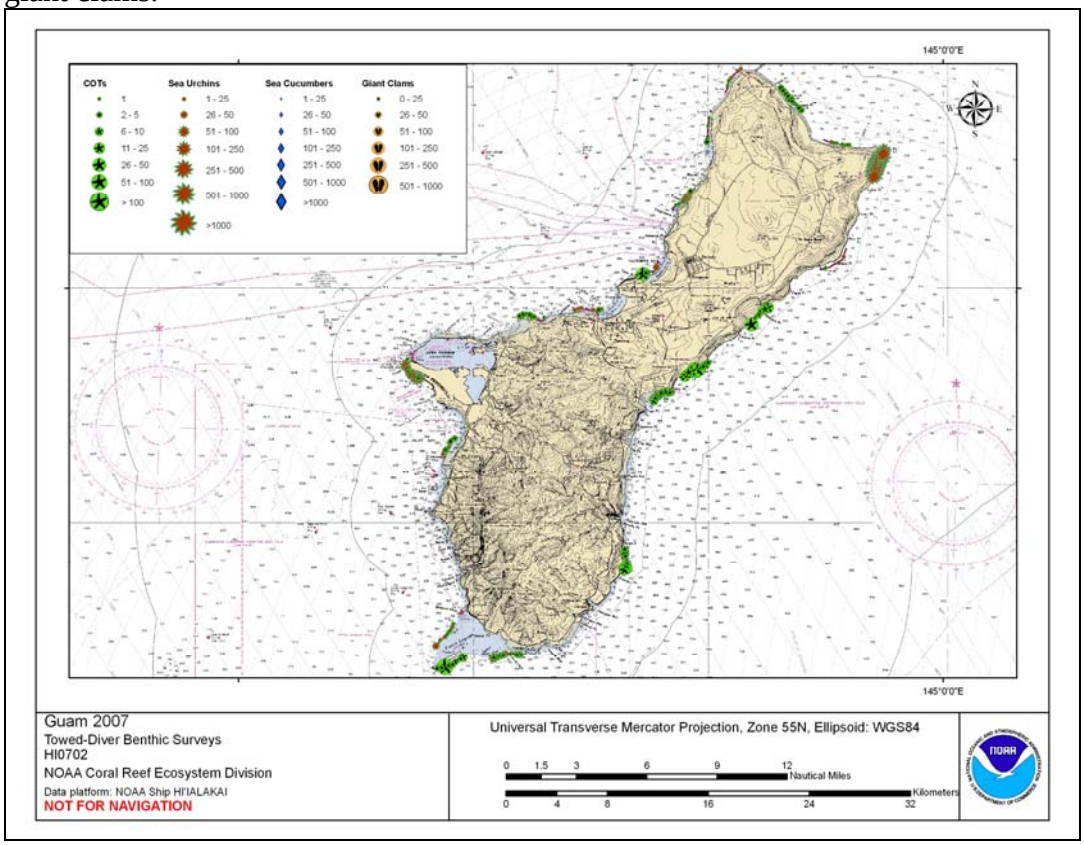

Figure B.4.3.1-1 Towed-diver macroinvertebrate observations at Guam for HI-07-02.

Guam

B.4.3.2 Invertebrate Collections

Acanthaster planci was collected in several locations around Guam:

Location	Date	Collector	Species	# of Samples	REA site	Site location	Habitat	Depth-ft	Lat deg	Lat min	Lon deg	Lon min
Guam	5/14/2007	Jason Kehn	*Acanthaster planci*	1	GUA-7	NE corner	Forereef	50	13	36.154	144	55.603
Guam	5/15/2007	Russell Moffitt	*Acanthaster planci*	6	GUA-11	East side, N of UOG Marine Lab	Forereef	33	13	25.697	144	48.608
Guam	5/15/2007	Russell Moffitt	*Acanthaster planci*	3	GUA-3	South point, east of Cocos Lagoon	Forereef	30	13	14.508	144	42.174
Guam	5/15/2007	Danny Merritt	*Acanthaster planci*	5	GUA-3	South point, east of Cocos Lagoon	Forereef	30 - 35	13	14.508	144	42.174
Guam	5/15/2007	Danny Merritt	*Acanthaster planci*	3	GUA-2	SW side; Fouha Bay	Forereef	20	13	18.300	144	39.174
Rota	5/16/2007	Russell Moffitt & Oceanography Team	*Acanthaster planci*	5	ROT-5	North Side	Forereef	35 - 50	14	10.991	145	12.405
Rota	5/17/2007	Allison Palmer	*Acanthaster planci*	2	ROT-3	SE Side	Forereef	35 - 50	14	6.858	145	10.031
Rota	5/17/2007	Allison Palmer	*Acanthaster planci*	4	ROT-7	Song Song Bay	Forereef	35 - 50	14	8.180	145	8.472
Rota	5/17/2007	Allison Palmer	*Acanthaster planci*	3	ROT-6	NW Side	Forereef	35	14	9.495	145	9.026
Rota	5/17/2007	Danny Merritt	*Acanthaster planci*	2	N/A		Forereef	20 - 35	14	12.562	145	12.16
Aguijan	5/18/2007	Allison Palmer	*Acanthaster planci*	1	AGU-3	NW Side	Forereef	45	14	51.5830	145	33.3590
Saipan	5/20/2007	Russell Moffitt	*Acanthaster planci*	3	SAI-3	SE Side, Kaulau Area	Forereef	20 - 45	15	9.364	145	46.185

B.5. Fish

B.5.1 REA Fish Surveys

Stationary Point Count data

A total of 40 individual SPC surveys were conducted at 10 forereef sites around the island of Guam. Divers enumerated fishes from 17 families and 55 species during the survey period. Parrotfishes (Scaridae) were the most abundant family and the largest contributor to biomass with 0.03 ton per hectare. Snappers (Lutjanidae), wrasses (Labridae), and triggerfish (Balistidae) were also commonly observed during the SPCs yielding biomasses of 0.010, 0.013, and 0.013 ton per hectare, respectively. Notable observations included a white-tip shark at site GUA-7. Sharks were rarely seen on or off survey area around Guam.

Belt-Transect data

During the survey period, 30 belt-transect surveys were conducted at 10 forereef sites around the island of Guam. Divers enumerated fishes from 23 families and 137 species during surveys. Damsels (Pomacentrids) were the most abundant fishes, but did not

significantly contribute to the overall biomass. Surgeonfish were the largest contributor to biomass with 0.04 ton per hectare. Wrasses (0.03 ton per hectare) and parrotfish (0.02 ton per hectare) were also relatively abundant and important contributors to fish biomass. Two observations of giant morays (*Gymnothorax javanicus*) along transects at site GUA-4 accounted for the large portion of biomass represented by this family (0.05 ton per hectare; Fig. B.5.1-1).

Overall observations

A total of 179 species were observed during the survey period by all divers. The medium to large fish biomass around Guam during the survey period was 0.12 ton/ha for the SPC surveys (Table B.5.1-1), and the total fish biomass was 0.20 ton/ha for the Belt transect surveys (Table B.5.1-2).

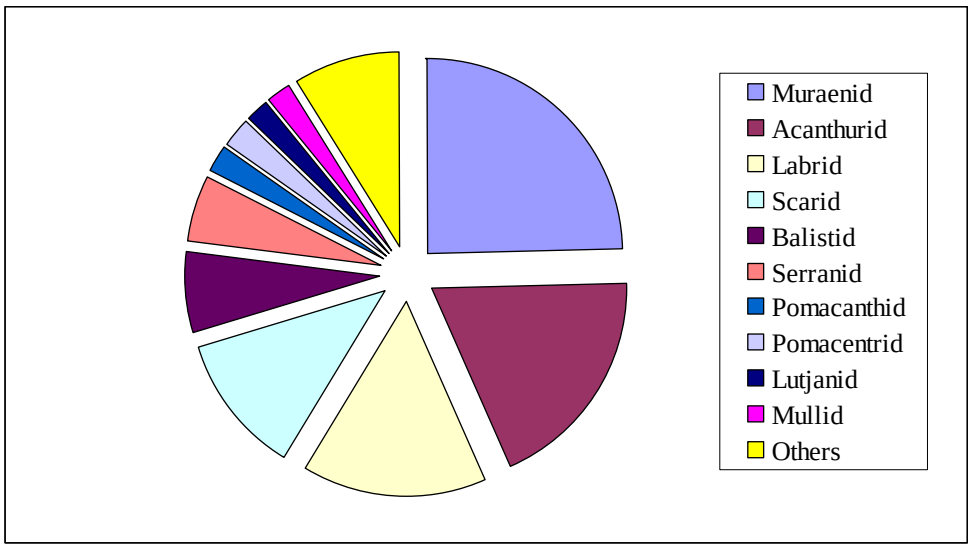

Figure B.5.1-1 – Family composition of the total fish biomass (0.20 ton per hectare) around Guam Island.

Table B.5.1-1 – Average medium to large fish biomass (tail length >25 cm) around Guam Island (ton per hectare).

Site	Total	Acanthurid	Balistid	Hemigaleid	Labrid	Lethrinid	Lutjanid	Scarid	Serranid	Others
GUA-1	0.03	0.00	0.000	0.000	0.000	0.000	0.000	0.028	0.000	0.003
GUA-2	0.12	0.02	0.019	0.000	0.009	0.012	0.010	0.034	0.008	0.004
GUA-3	0.02	0.00	0.000	0.000	0.005	0.011	0.002	0.000	0.000	0.002
GUA-4	0.11	0.01	0.036	0.000	0.019	0.000	0.011	0.018	0.000	0.019
GUA-5	0.06	0.00	0.000	0.000	0.010	0.003	0.000	0.052	0.000	0.000
GUA-7	0.48	0.00	0.046	0.286	0.018	0.000	0.032	0.039	0.062	0.000
GUA-8	0.03	0.01	0.000	0.000	0.000	0.000	0.011	0.008	0.000	0.000
GUA-9	0.15	0.02	0.029	0.000	0.017	0.010	0.011	0.026	0.000	0.040
GUA-10	0.07	0.00	0.000	0.000	0.013	0.000	0.005	0.041	0.000	0.009
GUA-11	0.13	0.01	0.000	0.000	0.039	0.000	0.016	0.051	0.001	0.007
Average	**0.18**	**0.007**	**0.013**	**0.029**	**0.013**	**0.004**	**0.010**	**0.030**	**0.007**	**0.008**

Table B.5.1-2 – Total fish biomass around Guam Island (ton per hectare)

Site	Total	Acanthurid	Balistid	Labrid	Lutjanid	Mullid	Muraenid	Pomacanthid	Pomacentrid	Scarid	Serranid	Others
GUA-1	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
GUA-2	0.11	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.03	0.00
GUA-3	0.13	0.05	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.02
GUA-4	0.61	0.04	0.01	0.02	0.00	0.01	0.48	0.00	0.01	0.02	0.00	0.02
GUA-5	0.10	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01
GUA-7	0.16	0.04	0.00	0.06	0.01	0.01	0.00	0.00	0.01	0.02	0.01	0.00
GUA-8	0.11	0.02	0.01	0.01	0.00	0.00	0.00	0.02	0.01	0.03	0.01	0.01
GUA-9	0.18	0.04	0.04	0.03	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.04
GUA-10	0.28	0.05	0.01	0.05	0.00	0.02	0.00	0.03	0.00	0.04	0.03	0.05
GUA-11	0.24	0.08	0.01	0.09	0.01	0.00	0.00	0.00	0.01	0.02	0.02	0.02
Average	**0.20**	**0.04**	**0.01**	**0.03**	**0.00**	**0.00**	**0.05**	**0.00**	**0.00**	**0.02**	**0.01**	**0.02**

B.5.2 Fish Towed-diver Surveys

At Guam, the Towboard team conducted 19 surveys totaling 45 kilometers in length and covering 45 hectares of ocean bottom. Mean survey length was 2.4 km. Fifty fish (>50 cm TL, all species spooled) were observed totaling 23 different species. Overall numeric density was 1.11 fish per hectare. Twinspot snapper (*Lutjanus bohar*), longface emperors (*Lethrinus olivaceus*), porcupinefish (*Diodon hystrix*), minifin parrotfish (*Scarus altipinnis*) and dogtooth tuna (*Gymnosarda unicolor*) were the five most commonly observed species (> 50 cm TL) at Guam during the survey period (Table B.5.2-1).

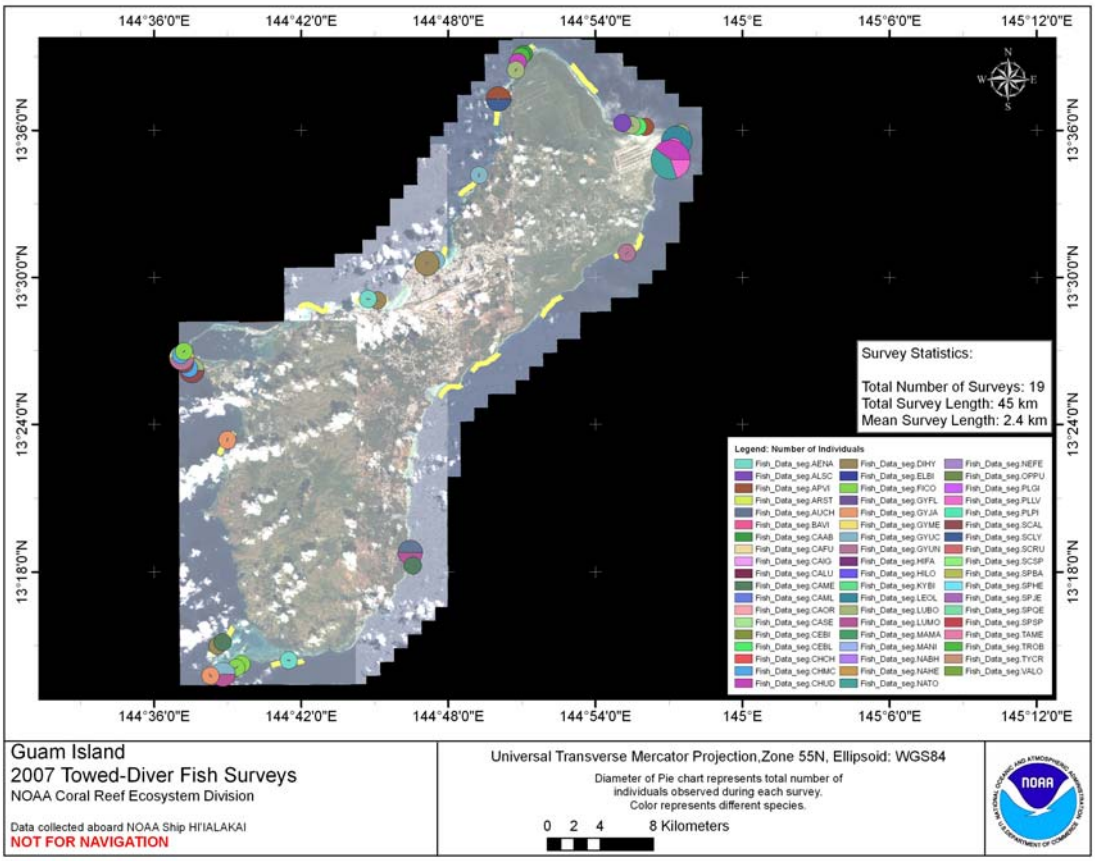

Figure B.5.2-1. Distribution of Large Fish Observations at Guam

Table B.5.2-1. Total number of individuals of each species observed at Guam.

Island	Taxon Name	#
Guam	Lutjanus bohar	5
	Lethrinus olivaceus	4
	Diodon hystrix	4
	Scarus altipinnis	3
	Gymnosarda unicolor	3
	Fistularia commersonii	3
	Cheilinus undulatus	3
	Plectropomus laevis	2
	Naso tonganus	2
	Lutjanus monostigma	2
	Chlorurus microrhinos	2
	Aprion virescens	2
	Caranx melampygus	2
	Aetobatus narinari	2
	Gymnothorax javanicus	2
	Gymnothorax undulatus	2
	Triaenodon obesus	1
	Aluterus scriptus	1
	Aulostomus chinensis	1
	Carcharhinus amblyrhynchos	1
	Cetoscarus bicolor	1
	Arothron stellatus	1
	Scomberoides lysan	1
Guam Total		50

Appendix C: Rota

C.1. Benthic Habitat Mapping

During HI-07-02 multibeam mapping surveys were conducted at Rota Island using the R/V *AHI*'s Reson 8101ER, and the *Hi'ialakai's* EM300 multibeam sonars. The *AHI* was deployed for 1 day and the *Hi'ialakai* surveyed for 2 nights and 2 days; total coverage at Rota was ~800 sq. km in water depths ranging from 10 to 2,000 m (Fig. C.1-1). R/V *AHI* mapping work with the Office of Coastal Survey was also conducted inside the harbor at Rota. Those data will be presented in a different report.

A small amount of multibeam bathymetry (~7.5 sq. km) had previously been acquired near the southwestern tip of Rota by the R/V *AHI* in 2003. On HI-07-02 additional *AHI* data were collected from ~20 to 200 m on the NW side of Rota. The shallow bathymetry shows a number of terraces related to previous stands of the sea. Deeper bathymetry collected by the *Hi'ialakai* show two NE-SW trending scarps extending offshore from the SW corner of Rota. Submarine canyons are best developed on the N side of Rota and amphitheater-shaped canyons are present on the E side of Rota. The latter are associated with large blocks of material probably related to mass wasting. Small blocks of material are present on the seafloor around all sides of Rota at a variety of depths. The origin of linear scarps with varied orientations on the NE side of Rota at ~1,000 m is uncertain.

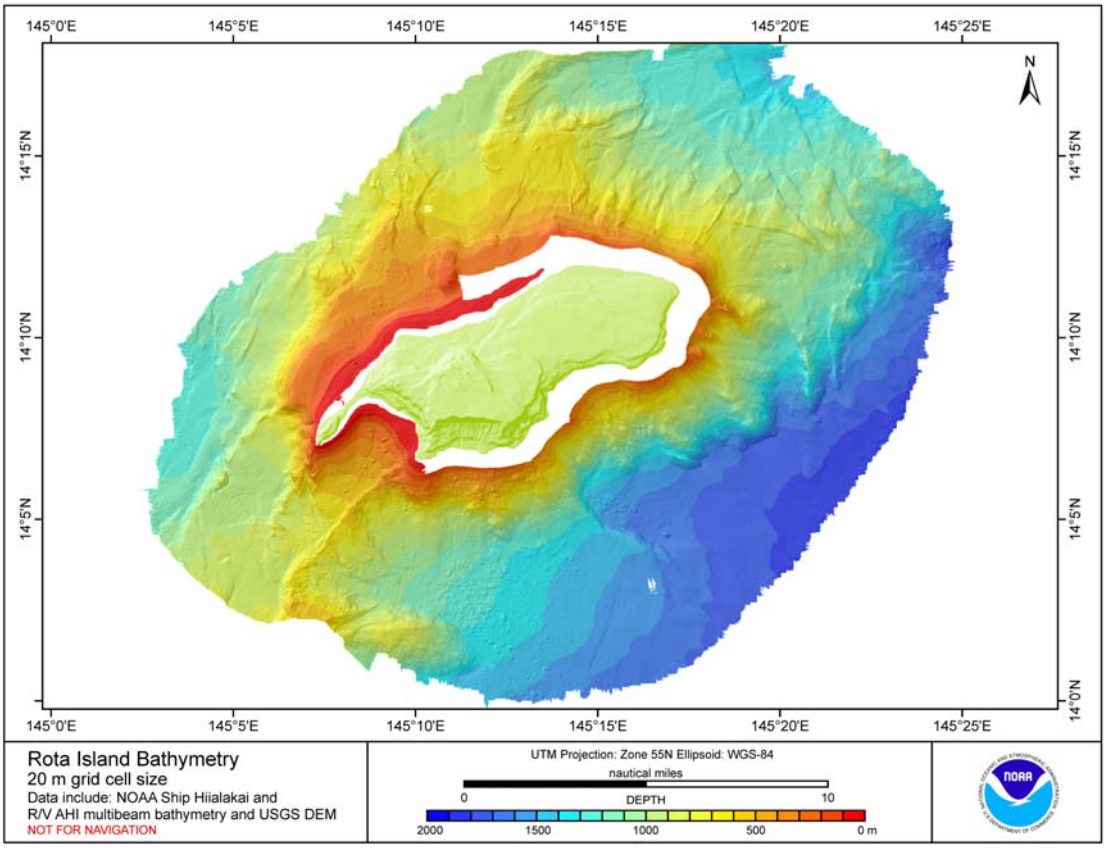

Figure C.1-1: Multibeam bathymetry of Rota shown with a USGS DEM.

C.2. Oceanography and Water Quality

In total, three instruments were recovered and four instruments were deployed at Rota during HI-07-02 (Fig. C.2-1). One sea surface temperature (SST) buoy and SST buoy anchor were removed and a new SST buoy and anchor were deployed, although the location was moved 50 m proximate to shore. One subsurface temperature recorder (STR) was attached to this SST anchor. Two STRs were recovered and replaced: one colocated with REA 5 on the northwest side of the island, and one on the northeast side of the island colocated with REA 1.

Twenty-nine shallow water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Rota at approximately 1 mile intervals following the 30-m contour. At five of these CTD locations, water sample profiles were performed concurrently, using a daisy chain of Niskin bottles at 1 m, 10 m, 20 m and 30 m depths, for a total of 44 discrete water samples measuring chlorophyll and nutrient concentrations.

In situ temperature data obtained from October 2005 to May 2007 shows seasonal variability with warm temperatures observed from July to November and cooler temperatures from January to April (Fig. C.2-2). In situ data are approximately 0.5 °C warmer than the climatological average from November 2005 to July 2006. This is followed by a particularly warm event during September/October 2006 when SST was ~1.0 °C above the climatological mean, reaching a maximum of 30.45 °C. In situ data show temperatures surpassing the bleaching threshold by 0.3 °C for approximately a week during this period. Subsequent to this warm period, and for the remainder of the time series, the in situ data follows the climatology rather closely.

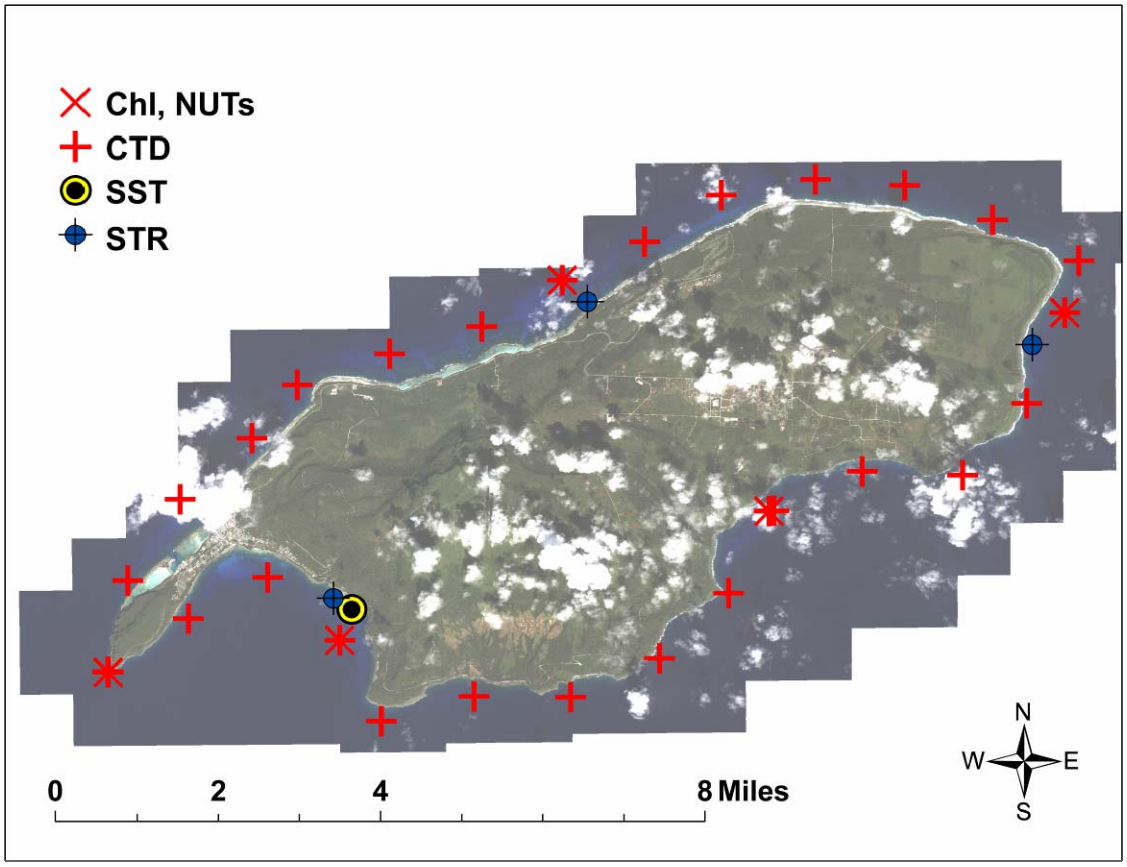

Figure C.2-1. Positions of CTDs, water samples, and moorings at Rota.

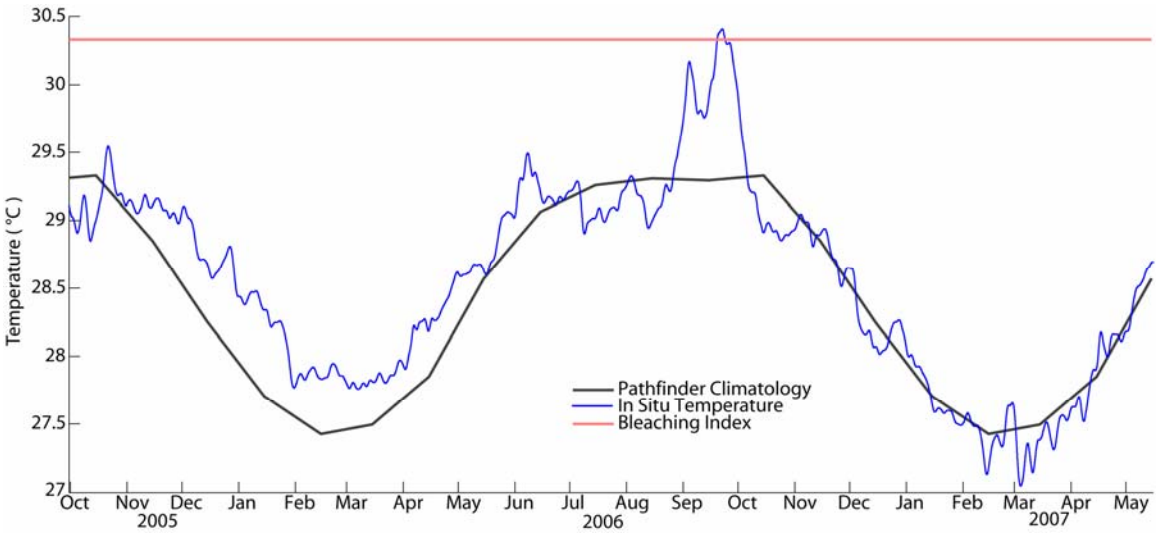

Figure C.2-2: In situ temperature time series from Rota overlaid with Pathfinder SST climatology, and including the coral reef bleaching index.

C.3 Rapid Ecological Assessment (REA) Site Descriptions

Rota: Fishing pressure is moderate around Rota. Cast netting, spear fishing, hook and line, and gleaning are the main fishing activities on this island. There is one no-take marine protected area on this island. Commercial fishing activities are moderate on this island. Gill netting is prohibited in the CNMI, except for traditional events.

REA surveys were conducted at six sites at Rota (Table C.3-1). Locations of all REA sites around Rota are shown in Figure C.3-1. The descriptions of each site are listed the order they were occupied by the REA team.

Table C.3-1. Sites surveyed by REA team at Rota, HI-07-02, May 2007. Depths and temperature are from Kenyon's dive gauge.

Site #	Date	Latitude (north)		Longitude (east)		Transect depth range, m	Max. depth, m	Temp, °C
ROT-5	5/16/07	14	10.991	145	12.405	12.1-13.9	15.8	28.3
ROT-1	5/16/07	14	10.510	145	17.148	10-12.1	19.1	28.9
ROT-2	5/16/07	14	9.209	145	15.547	12.1-14.5	15.2	28.9
ROT-3	5/17/07	14	6.858	145	10.031	11.2-19.2	19.4	28.9
ROT-7	5/17/07	14	8.180	145	8.472	7.2-9.1	10.9	28.9
ROT-6	5/17/07	14	9.495	145	9.026	12.7-13.9	17.9	28.9

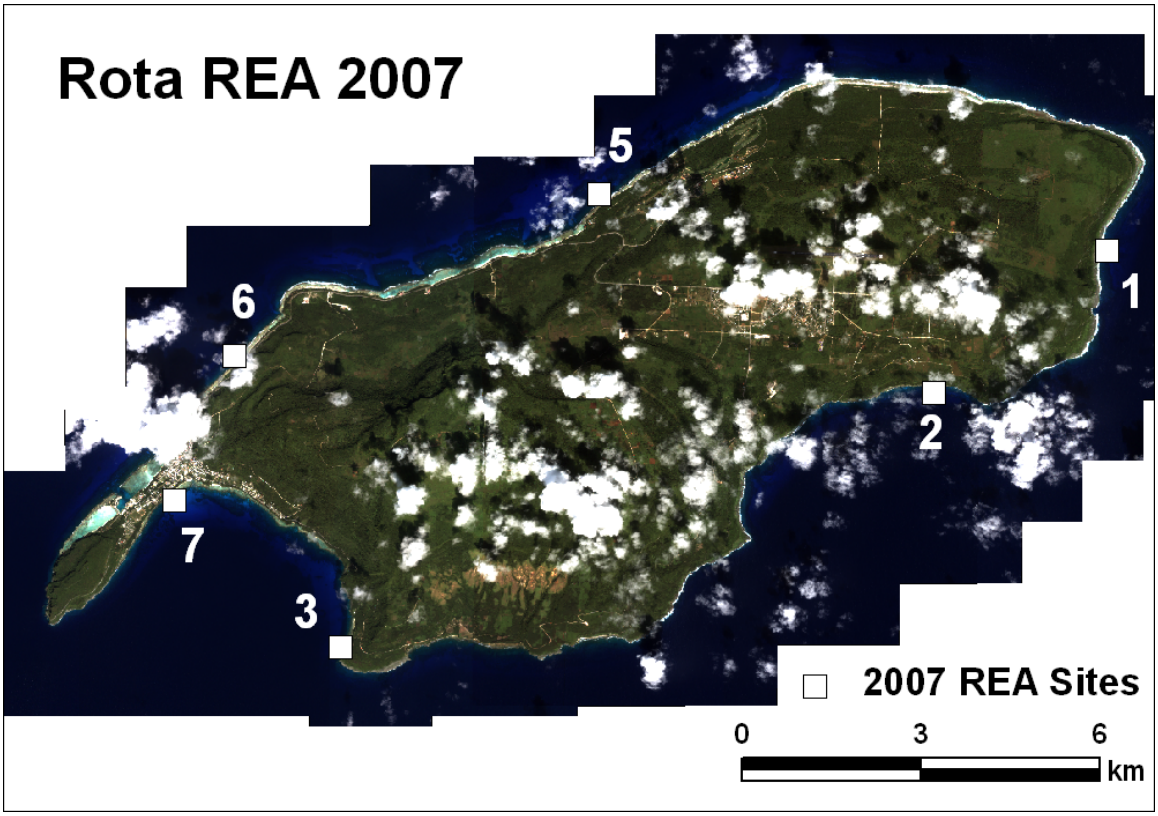

Figure C.3-1. Location of 2007 REA survey sites at Rota.

ROT-5
May 16, 2007
North side, transect depth 40–46 ft. Eighteen genera of scleractinian corals and two octocoral genera enumerated within 50 m^2. Two additional genera (*Plesiastrea, Euphyllia*) seen outside belt transects. Site numerically dominated by *Astreopora*. Low percent live coral cover (6.9%); dominated by small colonies of *Astreopora*. Turf-algae comprised over 70% of benthic cover, and macroalgal accounted for nearly 28%. Disease surveys report, within the survey area, two cases of bleaching and discolorations on *Astreopora*, 11 cases of coralline lethal orange disease, and 2 cases of COTS predation on *Astreopora*. Algae surveys report that the spur-and-groove forereef is characterized by turf algae, *Padina borgeseneii*, *Halimeda* spp., and *Avrainvaillea* spp. Other species collected on the transect were: *Amphiroa fragillisima, Caulerpa cupressoides, Caulerpa filicoides* var. *andamensis, Portieria hornemanii, Galaxaura cohaerens, Dictyota ceylanica*, and an unidentified fuzzy green mat (probably *Chlorodesmis* sp.). Species collected haphazardly included *Avrainvaillea lacerata, Dictyosphaeria versluysii, Asparagopsis taxiformis, Caulerpa sertularioides, Ventricaria ventricosa, and Liagora* sp.

ROT-1
May 16, 2007
East side, transect depth 33–40 ft. Topography of the two transects quite different: first transect had deep (60 ft) groove, while second transect was flat, algal-covered plain. Thirteen genera of scleractinian corals, two octocoral genera, and one hydrozoan (*Heliopora,* "blue coral") enumerated within 50 m^2. Three additional genera (*Hydnophora, Scapophyllia, Millepora*) seen outside belt transects. Unusually high abundance of *Heliopora* at the site, many > 40 cm diameter. Moderate percent live coral cover (23.5%); dominated by *Porites* (>70%), and the octocoral *Heliopora coerulea*. Turf-algae comprised nearly 60% of benthic cover. Disease surveys report one case of bleaching and discoloration on *Astreopora* and eight cases of coralline lethal orange disease. No cases of COTS predation were observed. Algae surveys report that this flat habitat was dominated by *Microdiction setchellianum*. Sponges were also very common. There was a slight surge, especially present in the one deep crevice located within the transect area. Species present at this depth included *Halimeda* spp., *Caulerpa* sp. *(C. cupressoides), Avrainvaillea* spp., *Padina borgeseneii, Rhipiliopsis* sp., *Neomeris* sp., and *Dictyosphaeria versluysii.* Species collected outside the transect area included *Caulerpa* sp. (mushroom-like), *Avrainvaillea erecta, Boodlea vanbossea,* and an unidentified green alga.

ROT-2
May 16, 2007
Southeast side, transect depth 40–48 ft. Fifteen genera of scleractinian corals and three octocoral genera enumerated within 50 m^2. Nine additional genera (*Plesiastrea, Acropora, Stylocoeniella, Montipora, Galaxea, Psammocora, Platygyra, Herpolitha, Seriatopora*) seen outside belt transects. Thus, very high coral diversity at the site. Low percent live coral cover (2.0%).The macroalga *Macrodictyon* comprised 49% of the benthic cover, and turf-algae accounted for over 33% of the living benthos.The

macroalga *Macrodictyon* comprised 49% of the benthic cover, and turf-algae accounted for over 33% of the living benthos. Disease surveys report only one case of coralline lethal orange disease within the survey area. Algae surveys report that the transect area was located on a relatively flat terrace that preceded a drop-off. Again, this community was dominated by sponges and *Microdiction setchellianum*. *Avrainvaillea* sp., *Halimeda* sp., green fuzz (sp. 1), *Jania capillacea, Boodlea vanbosseae, Galaxaura cohaerens,* and *Neomeris* sp. were also found in the transect area. Collected outside the transect area were *Avrainvaillea lacerata* and *Ventricaria ventricosa*.

ROT-3
May 17, 2007
SW side inside bay, transect depth 39–63 ft. Seven genera of scleractinian corals enumerated within 50 m^2. No additional genera seen outside belt transects. Lowest coral diversity of any site surveyed to date on HI-07-02. Site dominated by *Porites,* especially *Porites rus*. Spectacular formations of *P. rus*, some with high partial mortality with small colonies of other corals in dead spaces. Moderately high percent live coral cover (34.3%); dominated by small colonies of *Porites rus*. Turf-algae comprised over 48% of benthic cover, and macroalgae accounted for nearly 14%. Disease surveys report six cases of COTS predation on *Porites* spp.. Algae surveys report that very little algae were present but those that were present included *Halimeda opuntia, Amphiroa fragilissima, Tydemania expeditionis* and turfs. Collected outside the transect area were *Galaxaura cohaerens, Caulerpa* spp., and *Peyssonnelia* sp.

ROT-7
May 17, 2007
Song Song village bay, transect depth 24–30 ft. Eighteen genera of scleractinian corals, two octocoral genera, one hydrozoan (*Heliopora,* "blue coral"), and one other hexacoral (*Palythoa*) enumerated within 50 m^2. Four additional genera (*Lobophytum, Scapophyllia, Stylocoeniella, Turbinaria*) seen outside belt transects. High relief (structure) indicating robust reef accretion historically, but now eroded carbonate, very low (estimated <1%) coral cover). Used to be a reef here, but not anymore; a degraded remnant. Low percent live coral cover (4.9%). Turf-algae comprised nearly 78% of benthic cover.

ROT-6
May 17, 2007
NW side, transect depth 42–46 ft. Eighteen genera of scleractinian corals, one octocoral genus, and one hydrozoan genus enumerated within 50 m^2. Nine additional genera (*Gardineroseris, Scapophyllia, Echinopora, Oulophyllia, Turbinaria, Cycloseris, Leptoseris, Sarcophyton, Palythoa*) seen outside belt transects. Thus, very high coral diversity at the site, despite low percent cover (estimated 1%). Numerous small (<10 cm) colonies. Disease surveys report that, within the survey area, one case of coralline lethal orange disease was observed; additionally, two cases of COTS predation on *Pavona* and *Pocillopora* were observed. Algae surveys report that the dead pavement was covered with turf, blue-green and crustose coralline algae (CCA).

C.4. Benthic Environment

C.4.1. Algae

Tentatively for Guam and the southern CNMI, 45 macroalgae genera were found altogether: 37 known species (16 genera) of green algae (Chlorophyceae), 28 known species (25 genera) of red algae (Rhodophyceae), and 6 known species (4 genera) of brown algae (Phaeophyceae). Also, several unidentified species of filamentous algae were grouped into the functional category of turf algae and multiple species of cyanobacteria were found. Turf and calcified algae seem to do well on these wave-scoured islands. Subsequent to microscopic examination of samples, it is expected that with the identification of epiphytes and several species of macroalgae the number of species collected will increase substantially. Quantitative sites were all situated in depths of about 35-55 ft, mostly around 40 ft. A comprehensive algae list is shown below in Table C.4.1-1. Further examination of species is needed to increase accuracy and complete the list.

Table C.4.1-1. List of putative algae species in the southern Mariana Islands: Guam, Rota, Aguijan, Tinian, and Saipan.

Green algae	**Red algae**
Avrainvaillea erecta	*Amphiroa fragillissima*
Avrainvaillea lacerate	*Actinotrichia* sp.
Boergesenia forbesii	*Asparagopsis taxiformis*
Boodlea vanbosseae	*Botryocladia skottsbergii*
Bornetella oligospora	*Botryocladia tenuissima*
Bryopsis pennata	*Crouania* sp.
Caulerpa biserrulata	*Dichotomaria marginata*
Caulerpa cupressoides	*Galaxaura cohaerens*
Caulerpa elongata	*Gelidiella acerosa*
Caulerpa filicoides var. *andamanensis*	*Gelidiella pannosa*
Caulerpa geminata	*Gelidiopsis* sp.
Caulerpa nummularia	*Gibsmithia dotyi*
Caulerpa spp.	*Gibsmithia hawaiiensis*
Caulerpa racemosa var. *lamourouxii*	*Halymenia dilatata*
Caulerpa sertularioides	*Haloplegma duperreyi*
Caulerpa serrulata	*Jania capillacea*
Caulerpa taxifolia	*Liagora* sp.
Caulerpa webbiana	*Lobophora variegata*
Chlorodesmis hildebrandtii	*Mastophora rosea*
Codium bulbopilum	*Mesophyllum funagutiense*
Dictyosphaeria cavernosa	*Neurymenia fraxinifolia*

Green algae	Red algae
Dictyosphaeria versluysii	*Peyssonnelia inamoena*
Halimeda cuneata	*Platoma* cf. *ardreanum*
Halimeda cf. *discoidea*	*Portieria harveyi*
Halimeda lacunalis f. lata	*Portieria hornemannii*
Halimeda macroloba	*Predaea weldii*
Halimeda macrophysa	*Tolypocladia calodictyon*
Halimeda minima	*Tricleocarpa fragilis*
Halimeda opuntia	UNK SP. 1
Halimeda spp.	UNK SP. 2
Microdictyon setchellianum	UNK SP. 3 (UNK Sp. 2)
Neomeris van-bosseae	UNK SP. 4-red epiphyte
Neomeris spp.	**Brown algae**
Rhipiliopsis sp.	*Dictyota ceylanica*
Tydemania expeditionis	*Dictyota bartayresiana*
Valonia fastigiata	*Hydroclathrus clathrata*
Ventricaria ventricosa	*Padina boergesenii*
Unk. Species	*Turbinaria conoides*
Green mat/fuzz (Unk sp. 1)	*Turbinaria ornate*

Functional groups
Blue-green
Turf
CCA

Quantitative algal surveys were conducted at six sites outside Rota. All sites were previously surveyed in 2003 or 2005 and were comprised of forereef habitats within 150 m of shore or the northwestern reef flat. Time constraints prevented resurvey of the 2003 site ROT-04 on the northeast/windward side of the island. Many of the sites appeared to be heavily scoured by wave action.

Algal communites surveyed in Rota were usually covered in turf and blue-green algae. Most communities showed monotypic dominance with the most conspicuous macroalgae being *Halimeda* spp. and *Microdiction setchellianum*. Crustose coralline algae were also very prevalent at most sites. Relative abundance of algal species of Rota can be found in Table C.4.1-2 below.

Table C.4.1-2: Algal taxa or functional groups recorded in photoquadrats by site at Rota. First row of numbers indicates the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat.

	ROT-05	ROT-01	ROT-02	ROT-03	ROT-07	ROT-06
GREEN ALGAE						
Avrainvaillea erecta	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**1.0**	**2.2**	**0.0**	**0.0**	**0.0**
Avrainvaillea lacerata	8.3	8.3	58.3	0.0	0.0	0.0
	5.5	**4.0**	**3.8**	**0.0**	**0.0**	**0.0**
Boodlea vanbosseae	0.0	0.0	16.7	0.0	0.0	0.0
	0.0	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**
Caulerpa cupressoides	8.3	0.0	0.0	0.0	0.0	0.0
	4.0	**2.0**	**0.0**	**0.0**	**0.0**	**0.0**
Caulerpa filicoides var. *andamanensis*	16.7	0.0	0.0	0.0	0.0	8.3
	5.5	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**
Caulerpa spp.	0.0	50.0	8.3	0.0	0.0	0.0
	0.0	**2.0**	**5.0**	**0.0**	**0.0**	**0.0**
Caulerpa serrulata	0.0	0.0	0.0	0.0	8.3	25.0
	0.0	**0.0**	**0.0**	**4.0**	**2.0**	**4.3**
Dictyosphaeria versluysii	0.0	41.7	0.0	0.0	0.0	25.0
	0.0	**4.7**	**0.0**	**0.0**	**0.0**	**4.0**
Halimeda opuntia	0.0	8.3	0.0	66.7	0.0	0.0
	0.0	**1.0**	**0.0**	**2.3**	**0.0**	**0.0**
Halimeda spp.	83.3	75.0	83.3	0.0	0.0	83.3
	2.0	**1.9**	**3.0**	**0.0**	**0.0**	**1.4**
Microdictyon setchellianum	0.0	50.0	91.7	0.0	0.0	0.0
	0.0	**1.7**	**1.4**	**0.0**	**0.0**	**0.0**
Neomeris van-bosseae	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Neomeris spp.	16.7	25.0	8.3	0.0	0.0	0.0
	4.5	**4.7**	**6.0**	**5.0**	**0.0**	**0.0**
Rhipiliopsis sp.	0.0	50.0	0.0	0.0	0.0	0.0
	0.0	**2.3**	**0.0**	**0.0**	**0.0**	**0.0**
Tydemania	0.0	0.0	0.0	33.3	8.3	0.0

	ROT-05	ROT-01	ROT-02	ROT-03	ROT-07	ROT-06
expeditionis	**0.0**	**0.0**	**0.0**	**4.3**	**2.0**	**0.0**
Green mat/fuzz (Unk sp. 1) *Chlorodesmis?*	25.0	25.0	8.3	0.0	0.0	16.7
	5.3	**2.7**	**6.0**	**0.0**	**0.0**	**4.5**
RED ALGAE						
Amphiroa fragillissima	66.7	0.0	0.0	83.3	16.7	0.0
	2.8	**0.0**	**0.0**	**2.6**	**3.3**	**0.0**
Galaxaura cohaerens	0.0	0.0	8.3	0.0	0.0	0.0
	0.0	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**
Jania capillacea	0.0	0.0	16.7	0.0	0.0	0.0
	0.0	**0.0**	**3.0**	**0.0**	**0.0**	**0.0**
Mastophora rosea	0.0	0.0	0.0	0.0	8.3	0.0
	0.0	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**
Mesophyllum funagutiense	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Portieria hornemannii	16.7	0.0	0.0	0.0	0.0	0.0
	4.5	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Tolypocladia calodictyon	0.0	0.0	0.0	0.0	8.3	0.0
	0.0	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**
BROWN ALGAE						
Dictyota ceylanica	25.0	0.0	0.0	0.0	8.3	16.7
	4.3	**0.0**	**0.0**	**0.0**	**3.0**	**4.0**
Dictyota bartayresiana	8.3	0.0	0.0	0.0	0.0	0.0
	5.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Padina boergesenii	33.3	16.7	0.0	0.0	0.0	25.0
	3.2	**4.0**	**0.0**	**0.0**	**0.0**	**3.5**
FUNCTIONAL GROUPS						
Blue-green	50.0	25.0	41.7	66.7	33.3	58.3
	2.6	**3.0**	**2.2**	**2.1**	**2.4**	**2.9**
turf	41.7	0.0	41.7	25.0	83.3	66.7
	2.2	**0.0**	**3.2**	**4.3**	**1.2**	**2.3**
CCA	0.0	8.3	0.0	75.0	66.7	25.0
	0.0	**4.0**	**0.0**	**1.9**	**1.9**	**2.0**

C.4.1.2 Benthic Towed-diver Surveys – Macroalgae

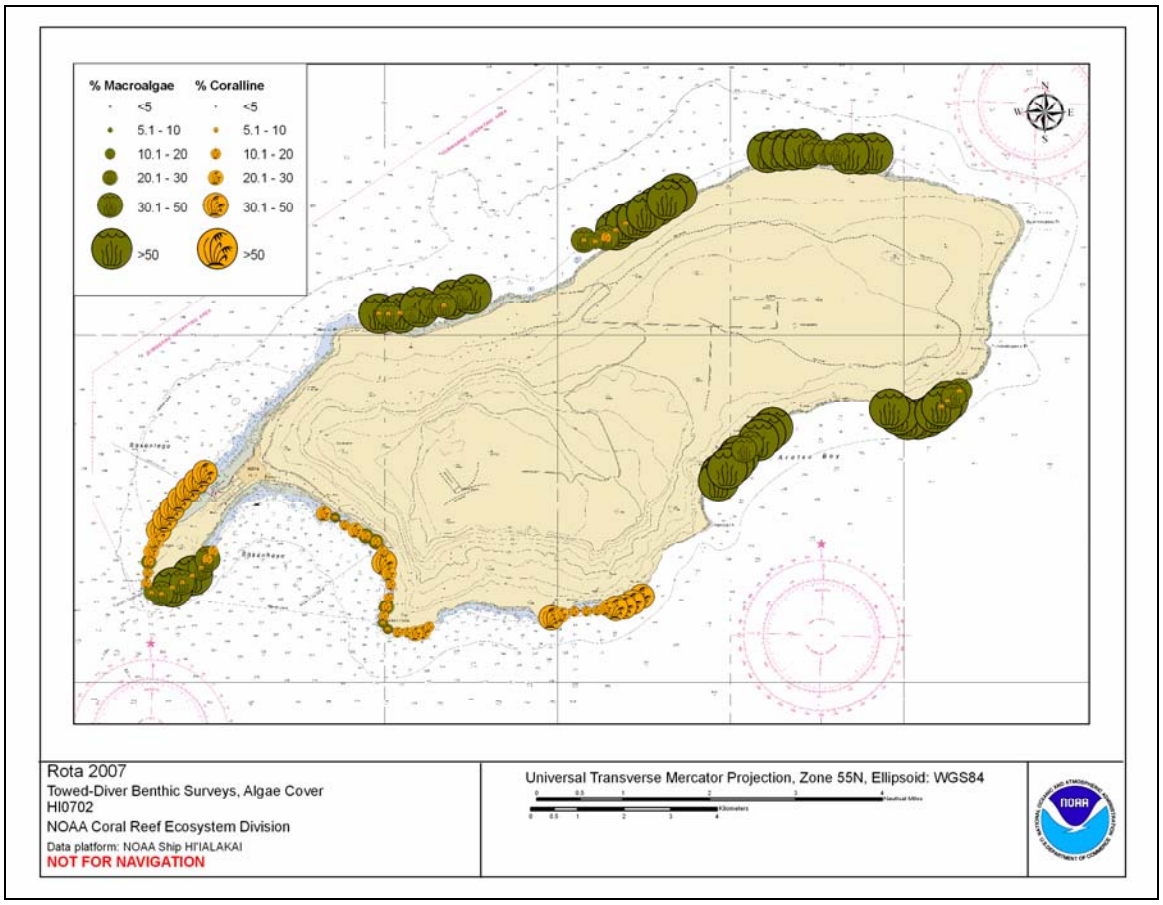

Figure C.4.1.2-1: Macroalgae and coralline algae cover around Rota (2007).

The macroalgae and coralline algae cover at Rota averaged 39% and 12% (range 1.1–100% and 0–40%, respectively). The highest macroalgae cover (average 36%, range 5.1 – 75%) was recorded during a towed-diver survey completed along the southeast corner passing Funiva Point. The survey was characterized by gentle slope, continuous reef flats and slight elevation changes ("rolling reef"). The benthos was algae dominated, largely by *microdictyon*. The highest coralline algae cover (average 12%, range 0–40%) was recorded along the western coast of the island, passing Taipingot and Anjota, ending near Mafuiion Rock.

C.4.2. Corals

C.4.2.1 Coral Populations

Coral Diversity and Population Parameters

A total of 1,307 cnidarian colonies were enumerated within belt transects covering 300 m^2 at Rota. These represented 28 cnidarian genera, of which 23 were scleractinian corals, 3 were octocorals (*Sinularia, Lobophytum, Sarcophyton*), 1 was a hydrozoan (*Heliopora*), and 1 was an additional hexacoral (*Palythoa*). The number of colonies

enumerated, and percentage of coral colonies represented by each taxon are shown in Table C.4.2.1-1. Ten additional taxa (*Leptoseris, Scapophyllia, Euphyllia, Plesiastrea, Hydnophora, Stylocoeniella, Herpolitha, Seriatopora, Gardineroseris,* and *Millepora*) not seen in belt transects were observed in the larger area around the transects in at least one site at Rota. Three genera (*Astreopora, Favia,* and *Porites*) each contributed more than 10% of the total number of colonies enumerated.

Table C.4.2.1-1. Number of cnidarians surveyed in belt transects at Rota sites in 2007. Taxa contributing more than 10% of the total number of coral colonies are in bold.

ROTA 2007		
Genus	# colonies	% of total
Acanthastrea	4	0.3
Acropora	6	0.5
Astreopora	133	**10.2**
Cycloseris	1	0.1
Cyphastrea	34	2.6
Echinopora	3	0.2
Favia	134	**10.3**
Favites	1	0.1
Fungia	11	0.8
Galaxea	23	1.8
Goniastrea	115	8.8
Goniopora	3	0.2
Heliopora	34	2.6
Leptastrea	59	4.5
Lobophytum	16	1.2
Montastrea	71	5.4
Montipora	8	0.6
Oulophyllia	18	1.4
Palythoa	2	0.2
Pavona	35	2.7
Platygyra	4	0.3
Pocillopora	35	2.7
Porites	476	**36.4**
Psammocora	2	0.2
Sarcophyton	5	0.4
Sinularia	29	2.2
Stylophora	45	3.4
Turbinaria	0	0.0
Total # colonies	1307	100.0
Area surveyed, m^2	300	

Size Class Structure

A size class distribution of all cnidarians enumerated within belt transects at Rota in 2007 is shown in Figure C.4.2.1-1. The majority (77.0%) of cnidarians were small, with a maximum estimated diameter of less than 10 cm.

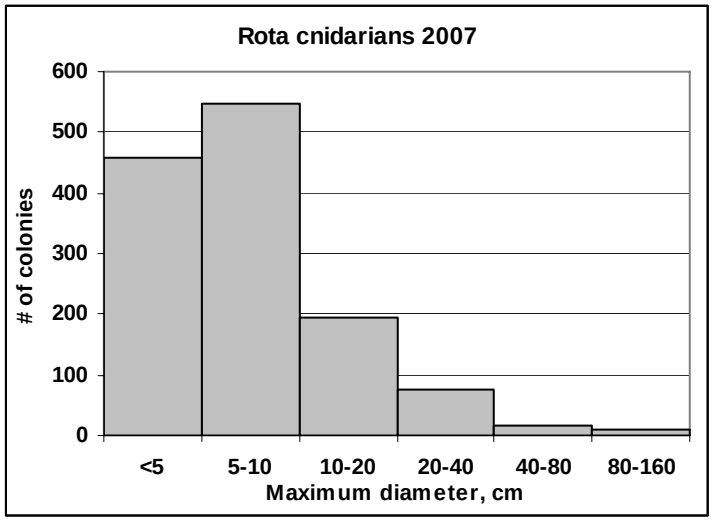

Figure C.4.2.1-1. Size class distributions of cnidarians enumerated in belt transects at Rota in 2007.

C.4.2.2 Percent Benthic Cover

In 2007, percent benthic cover surveys around Rota Island were conducted at six different sites. The line-intercept methodology quantified a total of 612 points along 300 m of forereef coral communities at depths ranging between 7 and 14 m. Patterns of intra-island variability in percent benthic cover, derived from the six independent REA surveys in 2007, are reflected in Figure C.4.2.2-1. Point-count surveys indicated that the mean percent live coral cover for all sites combined was moderately low: 12.4 ± 5.4% (mean ± SE). Highest coral cover was recoded at site ROT-3 (34.3%) on the south-facing shore; low percent coral cover (2.0 and 2.9%) was encountered at sites ROT-2 and -6, on the southeast and west sides of the island. Turf-algae and fleshy macroalgae including *Halimeda* were particularly abundant at most REA sites; together they comprised over 76% of the benthic cover. A total of 11 scleractinian genera were enumerated along the point-count transects, with *Porites* being the most numerically abundant (43.1 ± 11.9%), followed by *Stylophora* (16.7), and *Astreopora* (11.9%). Figure C.4.2.2-2 illustrates the contribution of the different scleractinain genera to the total percent live coral cover.

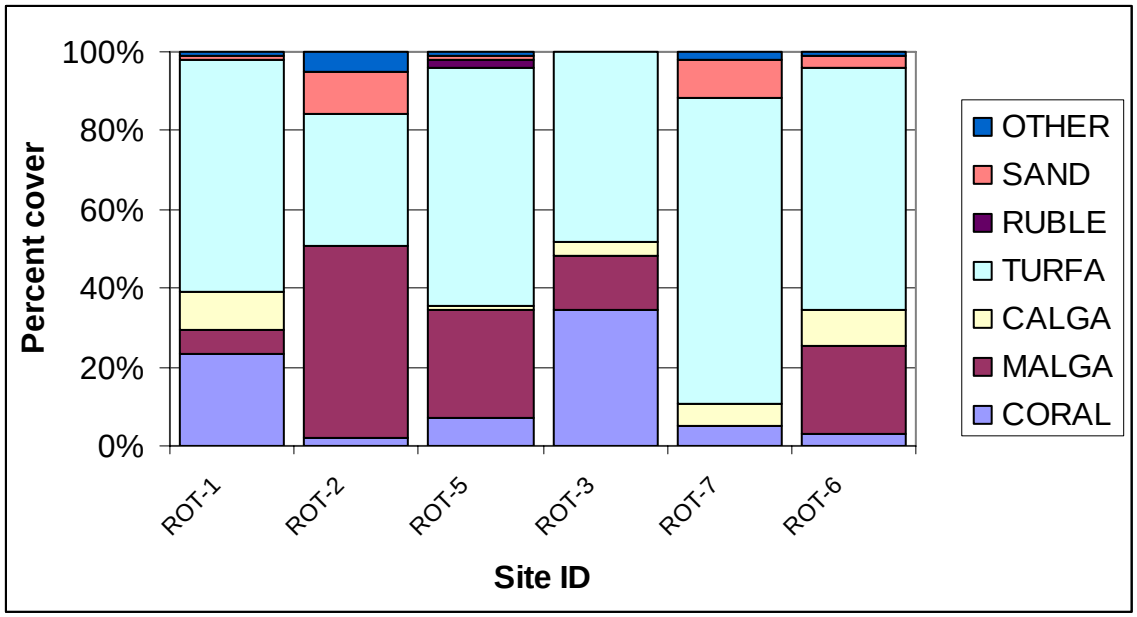

Figure C.4.2.2-1 Mean percent cover of selected benthic elements derived from six independent REA surveys at Rota Island, MAR-RAMP 2007. CORAL: live scleractinian and hydrozoan stony corals; MALGA: fleshy macroalgae; CALGA: crustose coralline algae; TURFA: turf-algae covered carbonate pavement; RUBLE: coral rubble (including recent and old coral rubble covered with turf-algae); SAND: sand; and OTHER: other sessile invertebrates including alcynoarian corals, echinoderms, sponges, tunicates, as well as cyanobacterial mats.

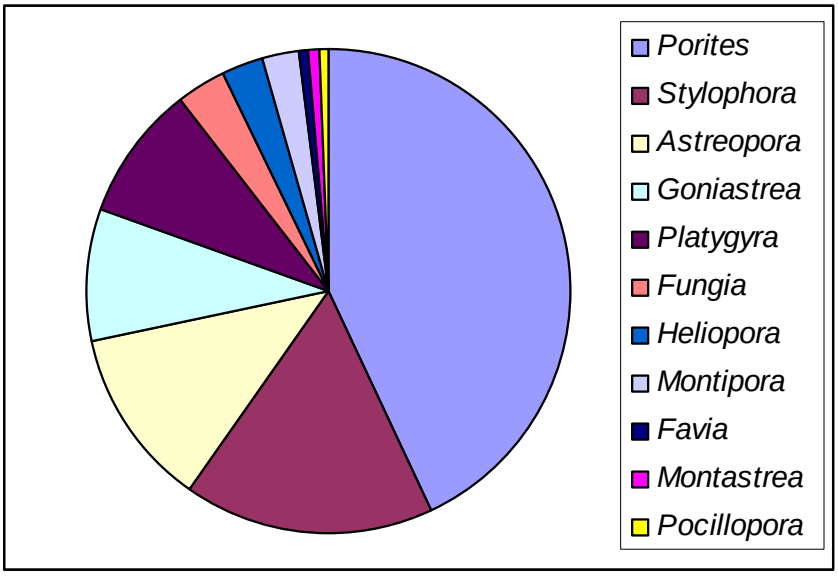

Figure C.4.2.2-2 Percent contribution of the different coral genera to the total live coral cover at Rota Island, MAR-RAMP 2007.

C.4.2.3 Coral Disease

In 2007, the coral disease REA surveyed a total area of ~1,725 m^2 at six different sites. A summary of disease occurrence is presented in Table C.4.2.3-1. Eighteen cases of disease were detected within the total area surveyed. Two main health conditions were observed: bleaching and discolorations (28%), as well as coralline algal diseases (72%). Among sites, ROT-1 on the east-facing shore exhibited the greatest occurrence of disease with nearly 50% of cases. Disease conditions, including bleaching and discoloration were registered on *Astreopora* only; a total of five cases were enumerated for all sites combined. Of particular interest, was the presence of Coralline Lethal Orange Disease (CLOD); a total of 13 lesions were recorded for all sites combined. For the most part, CLOD lesions were small (0.5–10 cm diameter). In addition, a total of 15 predation scars due to *Acanthaster planci* were enumerated within the total survey area.

Table C.4.2.3-1 Cumulative number of cases of disease conditions enumerated at each survey site around Rota Island during the 2007 RAMP cruise. BLE: bleaching; CLOD: Coralline lethal orange disease; and PRE: predation scars due to *Acanthaster planci.* Total survey area ~1,725 m^2.

DZ/HS1	ROT-1	ROT-2	ROT-5	ROT-3	ROT-7	ROT-6	Grand Total
BLE	1		2			2	5
CLOD	8	1	2		1	1	13
PRE			2	6	2	5	15
Grand Total	9	1	6	6	3	8	33

C.4.2.4 BenthicTtowed-diver Surveys – Corals

The average hard coral cover for Rota was recorded at 4% (range 0.1–75%), with stressed coral averaging 1% (range 0–20%). The highest average coral cover (average 17, range 0.1–75%) was noted during the towed-diver survey that bisected Pontan Pona and the east side of Sasanhaya Bay, where the terrain consisted of relatively consistent steep pavement slope with boulders at the bottom. Coral cover percentages spiked during segments 9 and 10 (62.5–75%), with the species component primarily composed of M*ontipora* and P*orites*. The corals often formed large pillars, extending upwards of 20 feet from the bottom, creating numerous overhangs and crevices.

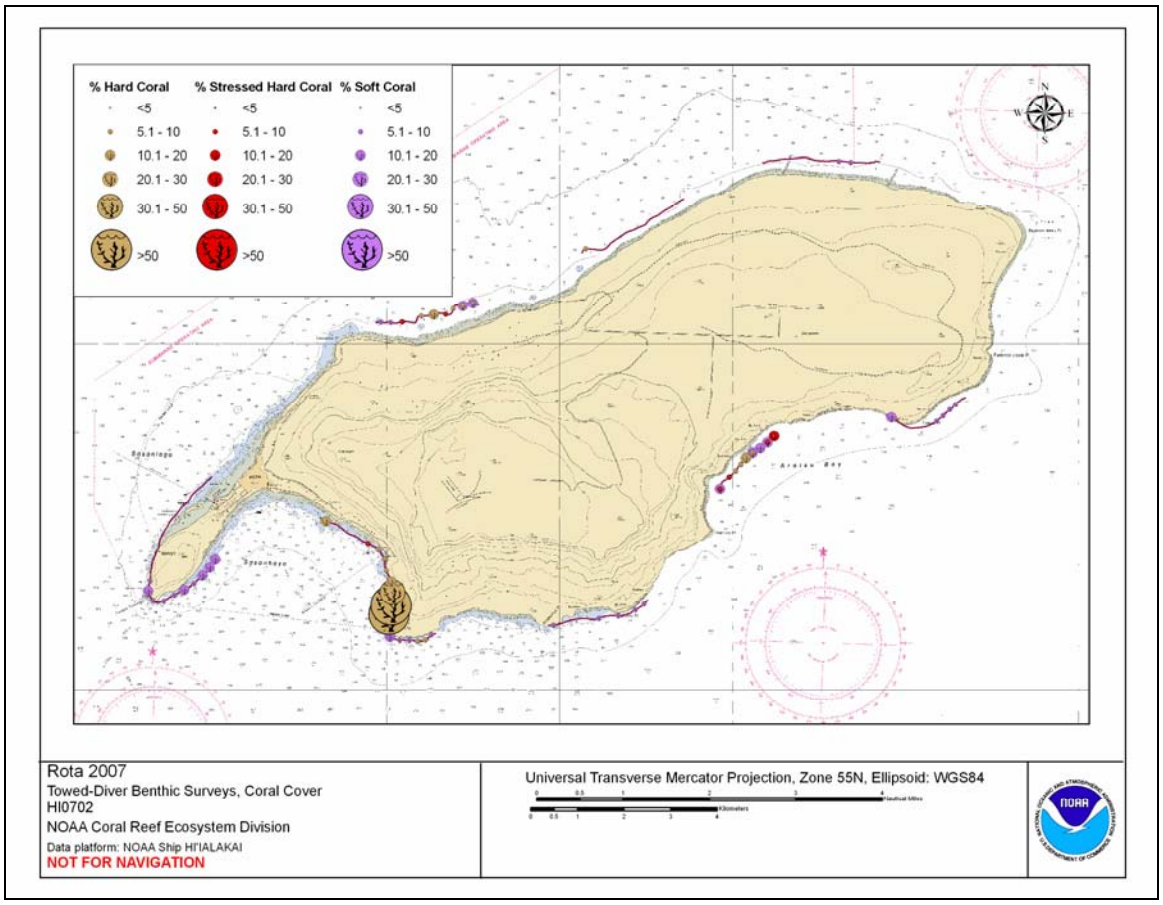

Figure C.4.2.4-1: Hard coral, stressed coral, and soft coral cover around Rota (2007).

The highest coral stress (average 6%, range 0–20%) was noted during the towed-diver survey in the southeast (Aratsu Bay), ending ~870 meters north of Hainiya Point. No additional observations regarding coral stressors were noted.

The average soft coral cover for Rota was 5% (range 0–20%). The highest overall soft coral cover was recorded during the towed-diver survey in the southeast (Aratsu Bay) ending north of Hainiya Point (average 11%, range 1.1–20%). In 5/10 time segments, percentages of soft coral cover ranged from 10.1–20%, with *sinularia* and *cladiella* noted within divers observations.

C.4.3 Macroinvertebrates

C.4.3.1 Benthic Towed-diver Surveys - Macroinvertebrates

The overall macroinvertebrate averages per survey for the island of Rota were 0.2 COTs, 102 sea urchins, 5.1 sea cucumbers, and 0.2 giant clams. Both COTs and Giant Clam numbers remained low throughout all surveys, individuals never exceeding two per 5-minute segment. Sea urchins were the most abundant macroinvertebrates recorded, with the highest populations observed along the west and southeast sides of the island. The west side surveys recorded significantly higher numbers of urchins, numbering as high as 1,001 per 5-minute segment. The habitat for each of these areas consisted of predominantly moderately sloped reef with large amounts of holes for the boring urchins to take cover. Sea cucumber numbers remained relatively constant with low counts throughout all surveys. A number of pin cushion sea stars were observed along the west side of the island, although minimal amounts of stressed hard corals were present.

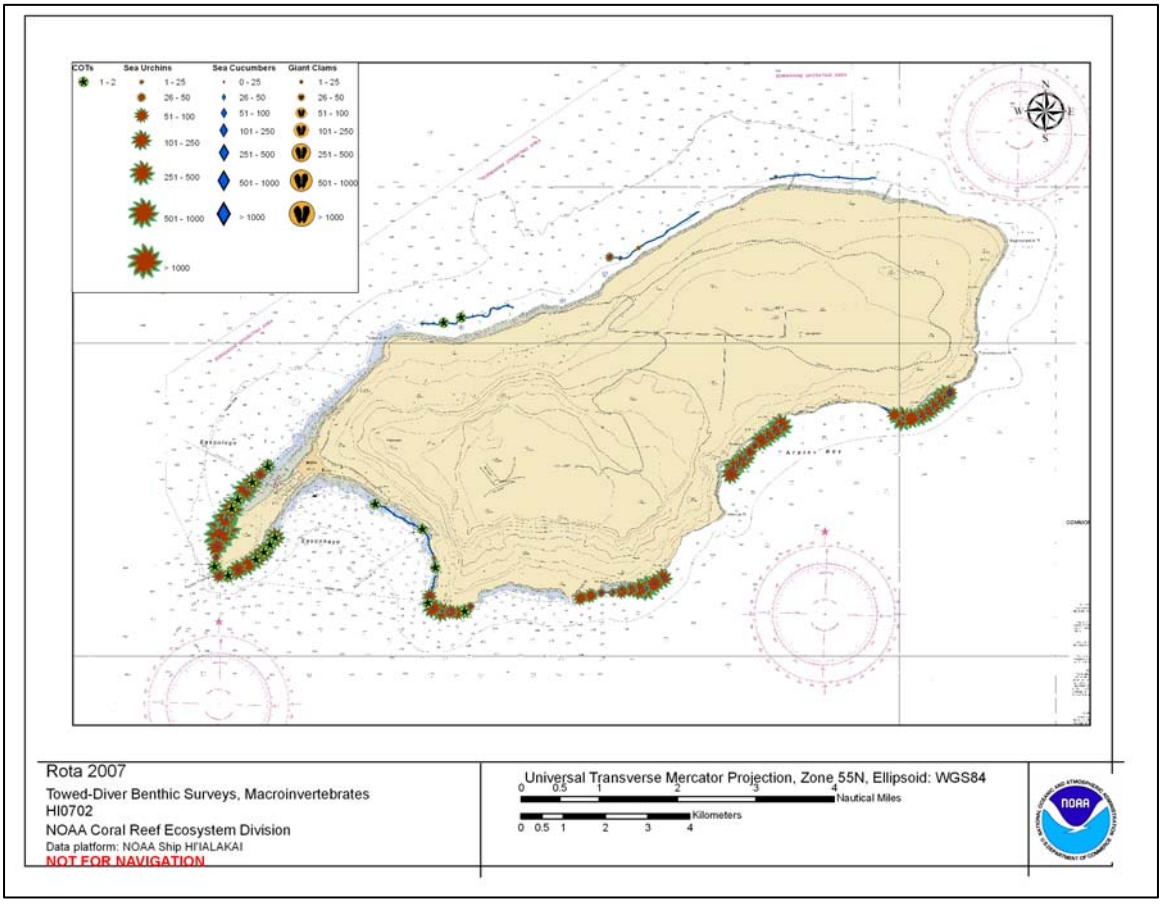

Figure C.4.3.1-1 Towed-diver macroinvertebrate observations at Rota for HI-07-02.

C.4.3.2 Invertebrate Collections

Acanthaster planci was collected at several locations around Rota:

Location	Date	Collector	Species	# of Samples	REA site	Site location	Habitat	Depth-ft	Lat deg	Lat min	Lon deg	Lon min
Rota	5/16/2007	Russell Moffitt & Oceanography Team	*Acanthaster planci*	5	ROT-5	North Side	Forereef	35 - 50	14	10.991	145	12.405
Rota	5/17/2007	Allison Palmer	*Acanthaster planci*	2	ROT-3	SE Side	Forereef	35 - 50	14	6.858	145	10.031
Rota	5/17/2007	Allison Palmer	*Acanthaster planci*	4	ROT-7	Song Song Bay	Forereef	35 - 50	14	8.180	145	8.472
Rota	5/17/2007	Allison Palmer	*Acanthaster planci*	3	ROT-6	NW Side	Forereef	35	14	9.495	145	9.026
Rota	5/17/2007	Danny Merritt	*Acanthaster planci*	2	N/A		Forereef	20 - 35	14	12.562	145	12.16

C.5. Fish

C.5.1 REA Fish Surveys

Stationary Point Count data
A total of 24 individual SPC surveys were conducted at six forereef sites around the island of Rota. Divers enumerated fishes from 18 families and 50 species during the survey period. Parrotfishes (Scaridae) were the most abundant family and the largest contributor to biomass with 0.111 ton per hectare. Snappers (Lutjanidae), wrasses (Labridae), and rabbitfish (Siganidae) were also commonly observed during the SPCs yielding biomass of 0.014, 0.008, and 0.008 ton per hectare, respectively.

Belt-Transect data
During the survey period, 18 belt-transect surveys were conducted at six forereef sites around the island of Rota. Divers enumerated fishes from 24 families and 126 species during surveys. Wrasses (Labrids) were the most abundant fishes, but were only the third largest contributer to the overall biomass with 0.010 ton per hectare. Damsels (Pomacentrids) were the second most abundant fishes, but did not contribute significantly to overall biomass (0.006 ton per hectare). Surgeonfish (Acanthurids) and Parrotfish (Scarids) were the primary contributors to biomass with 0.062 and 0.057 ton per hectare, respectively (Fig. C.5.1-1).

Overall observations
A total of 208 species from 35 families were observed during the survey period by all divers. The average medium to large fish biomass at the sites in Rota during the survey period was 0.24 ton/ha for the SPC surveys (Table C.5.1-1), and the average fish biomass was 0.19 ton/ha for the Belt transect surveys (Table C.5.1-2).

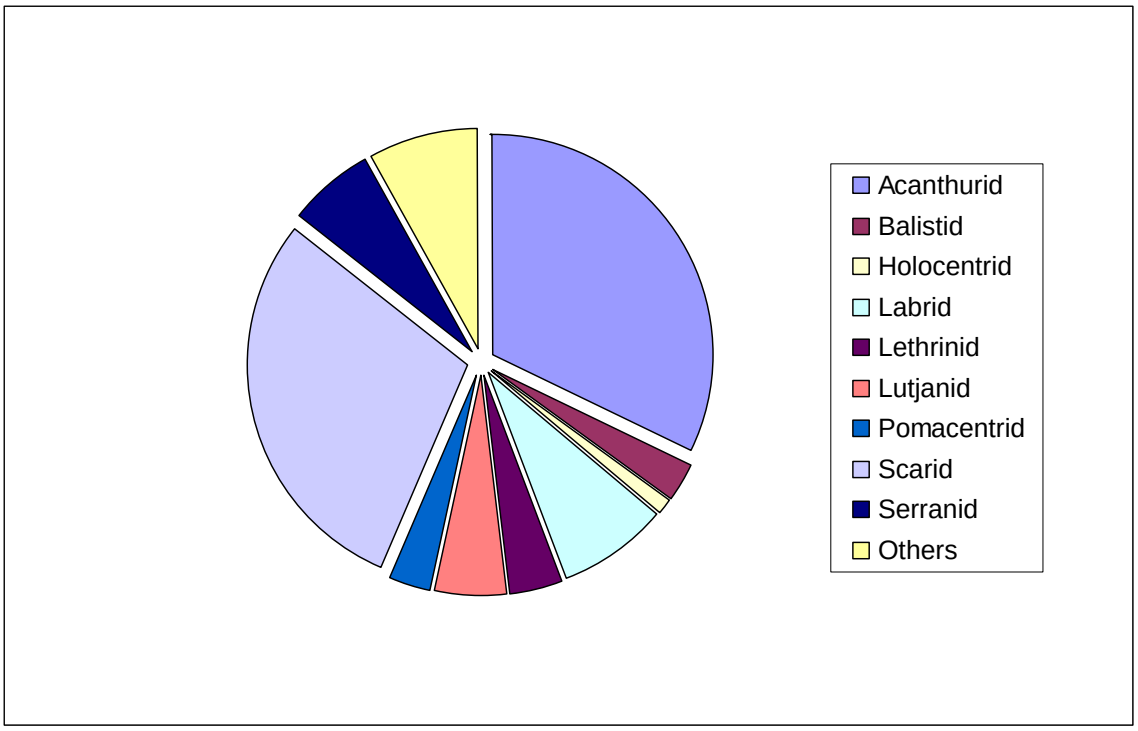

Figure C.5.1-1 – Family composition of the total fish biomass (0.19 ton per hectare) around the island of Rota.

Table C.5.1-1. Average medium to large fish biomass (tail length >25 cm) around the island of Rota (ton per hectare).

Site	Total	Acanthurid	Carangid	Hemigaleid	Labrid	Lethrinid	Lutjanid	Scarid	Serranid	Others
ROT-1	0.15	0.017	0.000	0.000	0.005	0.012	0.089	0.027	0.000	0.005
ROT-2	0.12	0.000	0.005	0.000	0.000	0.004	0.078	0.018	0.011	0.006
ROT-3	0.17	0.022	0.019	0.000	0.007	0.025	0.044	0.040	0.003	0.010
ROT-5	0.75	0.036	0.000	0.432	0.012	0.026	0.092	0.145	0.000	0.011
ROT-6	0.05	0.005	0.000	0.000	0.004	0.011	0.018	0.005	0.004	0.003
ROT-7	0.21	0.115	0.012	0.000	0.006	0.010	0.016	0.045	0.000	0.006
Average	**0.24**	**0.032**	**0.006**	**0.072**	**0.006**	**0.015**	**0.056**	**0.047**	**0.003**	**0.007**

Table C.5.1-2. Total fish biomass around the island of Rota (ton per hectare)

Sites	Total	Acanthurid	Balistid	Holocentrid	Labrid	Lethrinid	Lutjanid	Pomacentrid	Scarid	Serranid	Others
ROT-1	0.12	0.017	0.009	0.004	0.013	0.000	0.003	0.003	0.052	0.006	0.010
ROT-2	0.41	0.081	0.008	0.000	0.017	0.023	0.006	0.004	0.236	0.019	0.021
ROT-3	0.18	0.083	0.000	0.000	0.011	0.006	0.027	0.011	0.031	0.007	0.006
ROT-5	0.13	0.036	0.012	0.000	0.033	0.000	0.000	0.004	0.000	0.012	0.032
ROT-6	0.12	0.038	0.000	0.004	0.004	0.014	0.000	0.005	0.004	0.027	0.020
ROT-7	0.20	0.118	0.003	0.002	0.019	0.000	0.027	0.008	0.016	0.003	0.004
Average	**0.19**	**0.062**	**0.006**	**0.002**	**0.016**	**0.007**	**0.011**	**0.006**	**0.057**	**0.012**	**0.015**

C.5.2 Fish Towed-diver Surveys

At Rota, the Towboard team conducted 10 surveys totaling 23 kilometers in length and covering 23 hectares of ocean bottom. Mean survey length was 2.3 km. Fifty-two fish (>50 cm TL, all species spooled) were observed totaling 19 different species. Overall numeric density was 2.26 fish per hectare. Sleek unicornfish (*Naso hexacanthus*), *humphead wrasse (Cheilinus undulates)*, minifin parrotfish (*Scarus altipinnis*), bulbnose unicornfish (*Naso tonganus*), and yellowmargin morays (*Gymnothorax flavimarginatus*) were the five most commonly observed species (>50 cm TL) at Rota during the survey period (Table C.5.2-1).

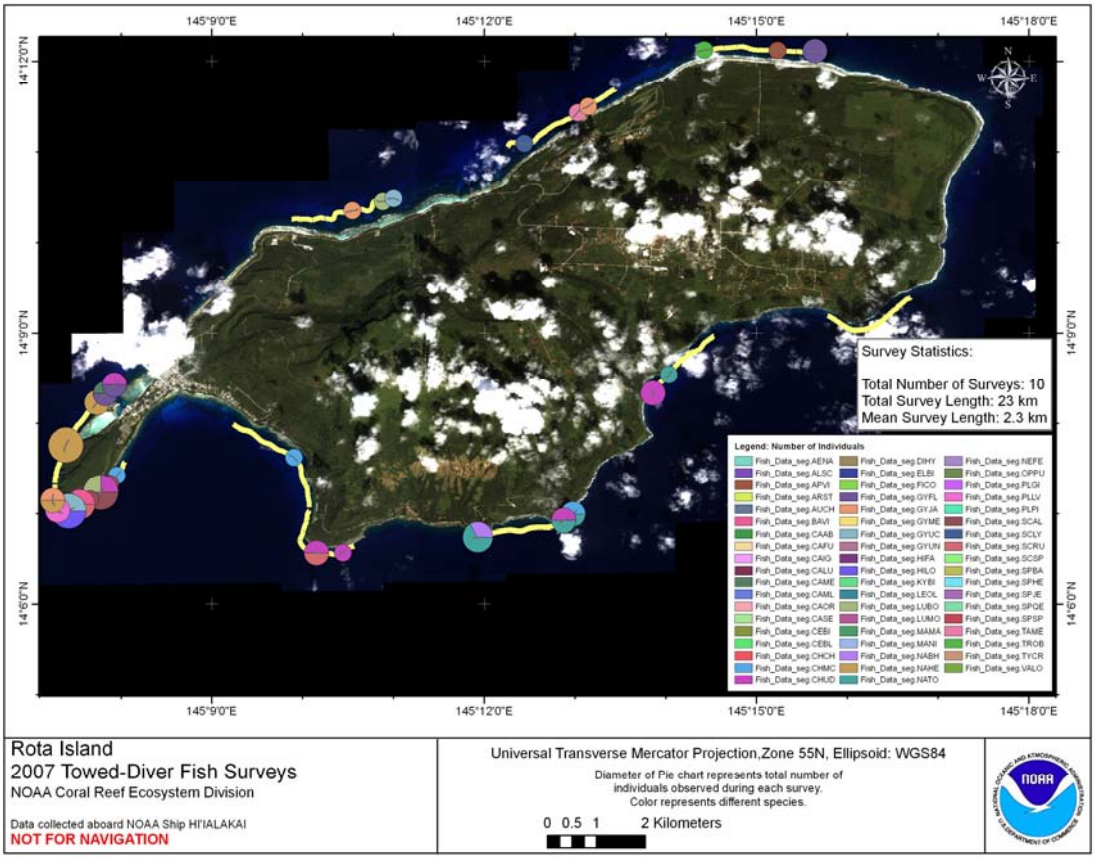

Figure C.5.2-1. Distribution of large fish observations at Rota.

Table C.5.2-1. Total number of individuals of each species observed at Rota.

Island	Taxon Name	#
Rota	Naso hexacanthus	7
	Cheilinus undulatus	7
	Scarus altipinnis	5
	Naso tonganus	5
	Gymnothorax flavimarginatus	4
	Gymnothorax javanicus	3
	Gymnosarda unicolor	3
	Chlorurus microrhinos	3
	Scarus rubroviolaceus	2
	Hipposcarus longiceps	2
	Lutjanus bohar	2
	Plectropomus laevis	2
	Triaenodon obesus	1
	Balistoides viridescens	1
	Aprion virescens	1
	Caranx melampygus	1
	Naso brachycentron	1
	Scomberoides lysan	1
	Taeniura meyeni	1
Rota Total		52

Appendix D: Aguijan

D.1. Benthic Habitat Mapping

During HI-07-02 multibeam mapping surveys were conducted at Aguijan Island using the *Hi'ialakai's* EM300 multibeam sonar. Total coverage by the *Hi'ialakai* at Saipan, Tinian, and Aguijan, combined, was ~1,800 sq. km within water depths ranging between 14 and 2,800 m (Fig. D.1-1).

Previous multibeam data was not collected around Aguijan before cruise HI-07-02. From the ~200 m and deeper, the *Hi'ialakai* was able to complete one pass around the island before going to Tinian Island. The bathymetry data reaches depths of about ~600 - 1000 m around Aguijan and about ~1,500 m at the edge of a transit line leading up to the island from the south. The banks diminish into deep ocean around the entire island except for a submerged ridge connecting it to Tinian's bank top on the northeast corner offshore.

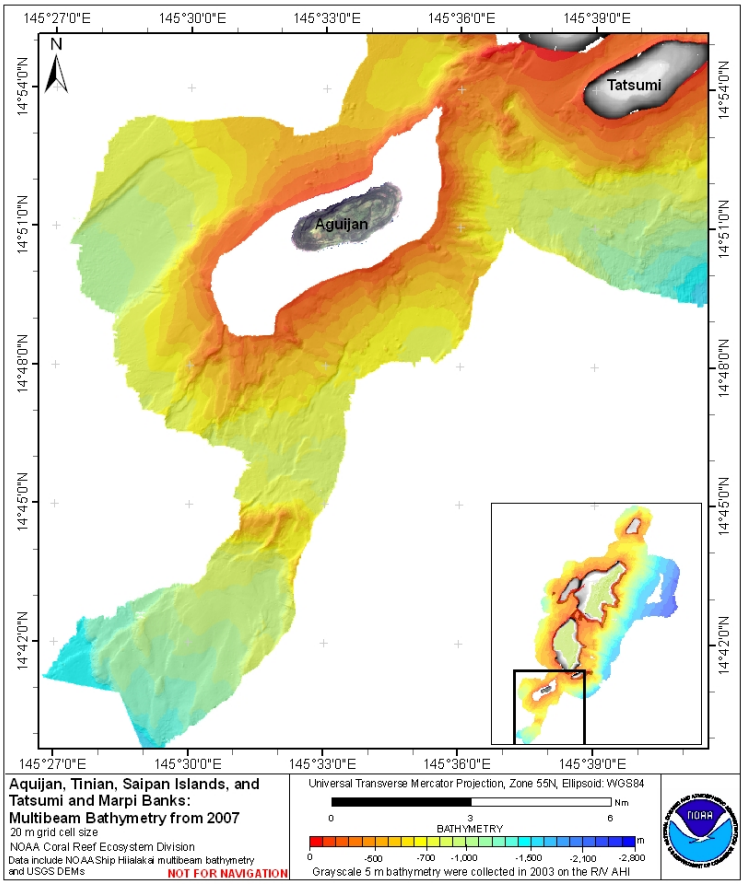

Figure D.1-1: Multibeam bathymetry of Tinian and Saipan, shown with a USGS DEM, and of Aguijan, with a USGS Digital Orthophoto Quadrangle Image.

A few deep canyons are cut in the slopes from the southwest part of Aguijan. The slopes to the north seem to connect with those coming from Tinian's west side, and the data reveal a depression northwest of Aguijan. Due to small boat mechanical problems, timing for a personnel transfer, and an afternoon transit to Saipan, the R/V *AHI* did not map at Aguijan.

D.2. Oceanography and Water Quality

One instrument, a subsurface temperature recorder (STR), was recovered and replaced at Aguijan during HI-07-02, colocated with REA 2 on the southwest side of the island (Fig. D.2-1).

Nineteen shallow water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Aguijan at approximately 0.5 mile intervals following the 30-m contour. At three of these CTD locations, water sample profiles were performed concurrently, using a daisy chain of Niskin bottles at 1 m, 10 m, 20 m and 30 m depths, for a total of 24 discrete water samples measuring chlorophyll and nutrient concentrations.

In situ temperature data at 3 m obtained from October 2005 to May 2007 shows seasonal variability with warm temperatures observed from July to November and cooler temperatures from January to April (Fig. D.2-2). In situ data are approximately 0.5 °C warmer than the climatological average from November 2005 to July 2006. This is followed by a particularly warm event during September/October 2006 when temperature was ~1.0 °C above the climatological mean, reaching a maximum of 30.4 °C. Subsequent to this warm period, and for the remainder of the time series, the in situ data follows the climatology rather closely.

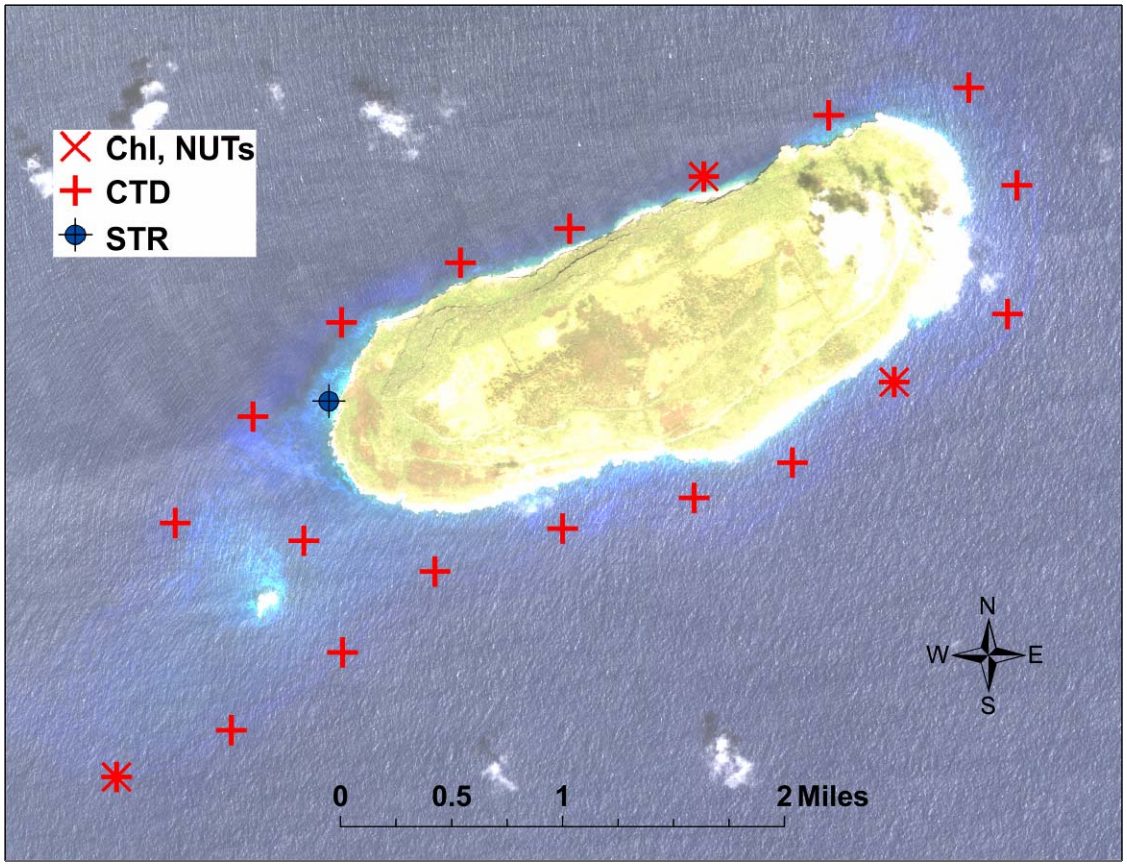

Figure D.2-1. Positions of CTDs, water samples and moorings at Aguijan.

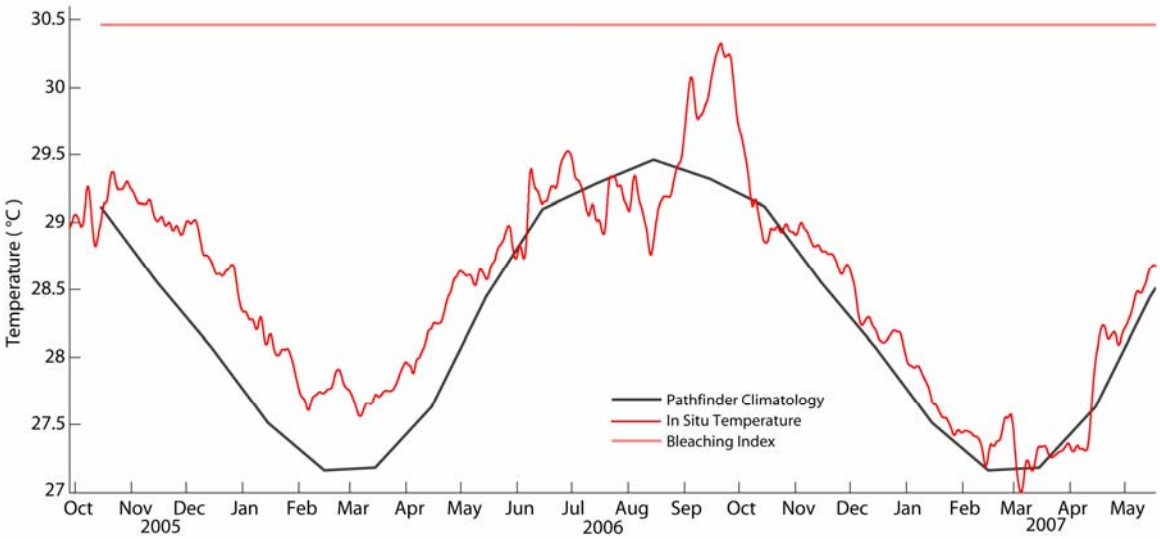

Figure D.2-2: In situ temperature time series from Aguijan overlaid with Pathfinder SST climatology, and including the coral reef bleaching index.

D.3 Rapid Ecological Assessment (REA) Site Descriptions

Aguijan: Fishing pressure is moderate around Aguijan. Most of the fishing pressure comes from Saipan and Tinian fishermen. A majority if the fishing activity is bottom fishing, with moderate spear fishing.

REA surveys were conducted at only one sites at Aguijan (Table B.3-1). The locations of the REA site at Aguijan is shown in Figure D.3-1.

Table D.3-1. Sites surveyed by REA team at Aguijan, HI-07-02, May 2007. Depths and temperature are from Kenyon's dive gauge.

Site #	Date	Latitude (north)		Longitude (east)		Transect depth range, m	Max. depth, m	Temp, °C
AGU-3	5/18/07	14	51.583	145	33.359	12.1-13.3	20.9	28.8

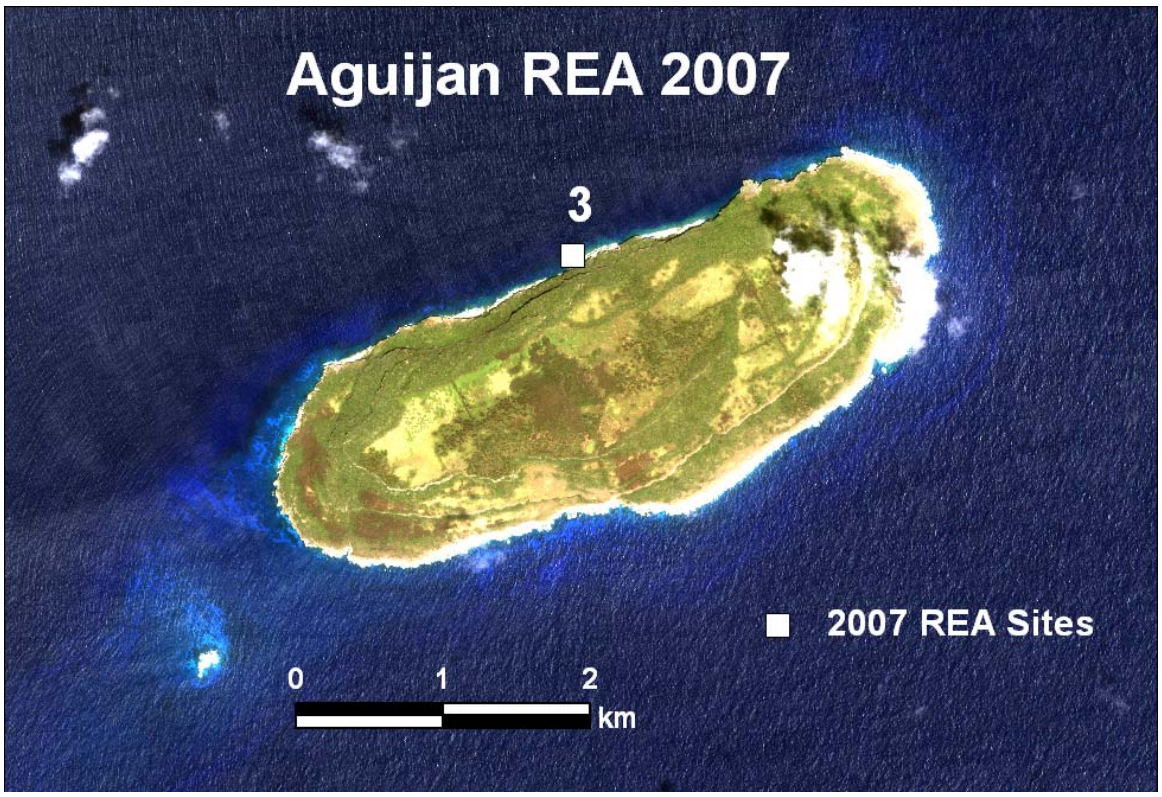

Figure D.3-1. Location of 2007 REA survey site at Aguijan.

AGU-3
May 18, 2007
North side, transect depth 40–44 ft, plus deep groove (~80 ft) in middle of first transect. High relief/structure with heavy coralline algal cover but low live coral cover. Reef structure not highly eroded; coralline-algal covered outlines of dead colonies clearly visible. Large colonies of *Pavona duedeni* now mostly dead, some of remnants live

tissue. Several large colonies *Gardineroseris* and *Coscinaraea* in the area. Thirteen genera of scleractinian corals, two octocoral genera, one hydrozoan (*Heliopora*) and one other hexacoral (*Palythoa*) enumerated within 50 m^2. Three additional genera (*Lobophyllia*, *Oulophyllia*, *Fungia*) seen outside belt transects. Low percent live coral cover (7.8%), with a few large colonies of *Gardineroseris planulata*. Pavement covered on turf-algae comprised over 49% of benthic cover, and crustose coralline algae accounted for over 32%. Disease surveys reported two cases of white syndrome on *Gardineroseris planulata*, as well as one case of cyanobacterial infection on *G. planulata*. Additionally, 30 cases of coralline lethal orange disease were enumerated. Algae surveys report that the pavement was covered mostly with crustose coralline algae and turf, though some areas were barren. *Halimeda opuntia* was apparent in some of the cracks and crevices and was probably the most dominant algae surrounding the transect area. Several other species were collected outside the transect area. *Predaea weldii* was found at 60 ft.

D.4. Benthic Environment

D.4.1. Algae

Tentatively for Guam and the southern CNMI, 45 macroalgae genera were found altogether: 37 known species (16 genera) of green algae (Chlorophyceae), 28 known species (25 genera) of red algae (Rhodophyceae), and 6 known species (4 genera) of brown algae (Phaeophyceae). Also, several unidentified species of filamentous algae were grouped into the functional category of turf algae, and multiple species of cyanobacteria were found. Turf and calcified algae seem to do well on these wave-scoured islands. Subsequent to microscopic examination of samples, it is expected that with the identification of epiphytes and several species of macroalgae the number of species collected will increase substantially. Quantitative sites were all situated in depths of about 35-55 ft, mostly around 40 ft. A comprehensive algae list is shown below in Table D.4.1-1. Further examination of species is needed to increase accuracy and complete the list.

Table D.4.1-1. List of putative algae species in the southern Mariana Islands: Guam, Rota, Aguijan, Tinian, and Saipan.

Green algae	**Red algae**
Avrainvaillea erecta	*Amphiroa fragillissima*
Avrainvaillea lacerate	*Actinotrichia* sp.
Boergesenia forbesii	*Asparagopsis taxiformis*
Boodlea vanbosseae	*Botryocladia skottsbergii*
Bornetella oligospora	*Botryocladia tenuissima*
Bryopsis pennata	*Crouania* sp.
Caulerpa biserrulata	*Dichotomaria marginata*
Caulerpa cupressoides	*Galaxaura cohaerens*
Caulerpa elongata	*Gelidiella acerosa*

Green algae	Red algae
Caulerpa filicoides var. *andamanensis*	*Gelidiella pannosa*
Caulerpa geminata	*Gelidiopsis* sp.
Caulerpa nummularia	*Gibsmithia dotyi*
Caulerpa spp.	*Gibsmithia hawaiiensis*
Caulerpa racemosa var. *lamourouxii*	*Halymenia dilatata*
Caulerpa sertularioides	*Haloplegma duperreyi*
Caulerpa serrulata	*Jania capillacea*
Caulerpa taxifolia	*Liagora* sp.
Caulerpa webbiana	*Lobophora variegata*
Chlorodesmis hildebrandtii	*Mastophora rosea*
Codium bulbopilum	*Mesophyllum funagutiense*
Dictyosphaeria cavernosa	*Neurymenia fraxinifolia*
Dictyosphaeria versluysii	*Peyssonnelia inamoena*
Halimeda cuneata	*Platoma* cf. *ardreanum*
Halimeda cf. *discoidea*	*Portieria harveyi*
Halimeda lacunalis f. lata	*Portieria hornemannii*
Halimeda macroloba	*Predaea weldii*
Halimeda macrophysa	*Tolypocladia calodictyon*
Halimeda minima	*Tricleocarpa fragilis*
Halimeda opuntia	UNK SP. 1
Halimeda spp.	UNK SP. 2
Microdictyon setchellianum	UNK SP. 3 (UNK Sp. 2)
Neomeris van-bosseae	UNK SP. 4-red epiphyte
Neomeris spp.	**Brown algae**
Rhipiliopsis sp.	*Dictyota ceylanica*
Tydemania expeditionis	*Dictyota bartayresiana*
Valonia fastigiata	*Hydroclathrus clathrata*
Ventricaria ventricosa	*Padina boergesenii*
Unk. Species	*Turbinaria conoides*
Green mat/fuzz (Unk sp. 1)	*Turbinaria ornate*
Functional groups	
Blue-green	
Turf	
CCA	

The algal team was only able to survey one site at Aguijan (AGU-02) due to time constraints and a strong current at site AGU-01, making it difficult to collect meaningful data. AGU-02 on the west side was comprised of pavement covered mostly with crustose

coralline algae and turf, although some areas were barren. Several other species were collected outside the transect area including *Predaea weldii*, found at 60 ft. See Table 2-D.4.1-2 below for algae relative abundance.

Table D.4.1-2: Algal taxa or functional groups recorded in photoquadrats by site at Aguijan. First row of numbers indicates the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat.

	AGU-02
GREEN ALGAE	
Halimeda opuntia	33.3
	1.5
RED ALGAE	
Jania capillacea	25.0
	2.3
Portieria hornemannii	16.7
	3.0
FUNCTIONAL GROUPS	
Blue-green	16.7
	2.5
turf	16.7
	1.0
CCA	75.0
	1.2

D.4.1.2 Benthic Towed-diver Surveys – Macroalgae

The macroalgae and coralline algae cover at Aguijan averaged 28% and 13% (range 0–75% and 1.1–40%, respectively). The highest macroalgae cover was recorded during a survey completed moving from the northeast to the southeast section of the island (average 36%, range 5.1–75%). The survey was characterized by cliffs, coral pavement/continuous reef, wide spur and groove, and moderate or steep slopes. Later sections noted an increase in algae cover (esp. *Halimeda* and *Microdictyon*) in areas of continuous reef habitat. The highest coralline algae cover (average 17%, range 1.1–40%) was recorded along the western coast of the island (moving northwest to southwest).

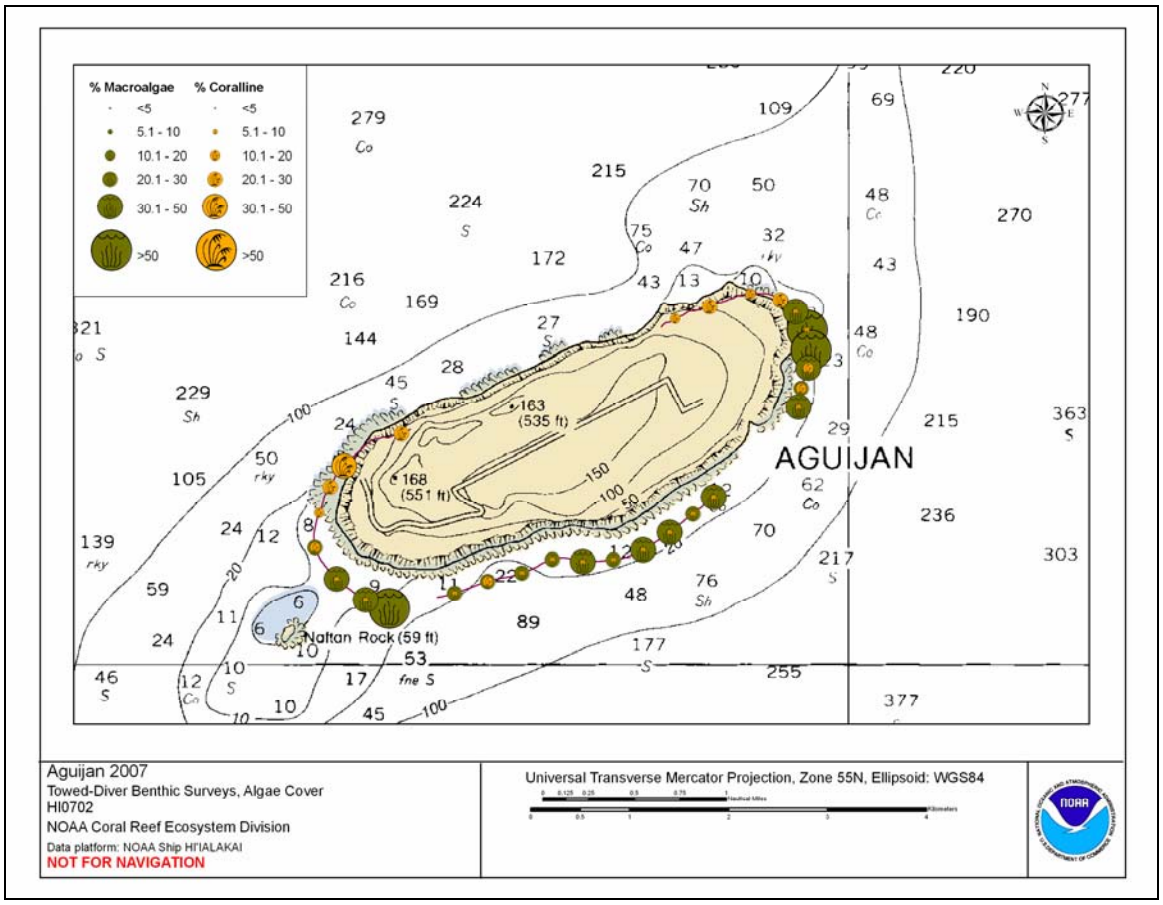

Figure D.4.1.2-1: Macroalgae and coralline algae cover around Aguijan (2007).

D.4.2. Corals

D.4.2.1 Coral Populations

Coral Diversity and Population Parameters

A total of 1,307 cnidarian colonies were enumerated within belt transects covering 50 m^2 at Aguijan. These represented 17 cnidarian genera, of which 13 were scleractinian corals, two were octocorals (*Sinularia, Lobophytum*), one was a hydrozoan (*Heliopora*), and one was an additional hexacoral (*Palythoa*). The number of colonies enumerated and percentage of coral colonies represented by each taxon are shown in Table D.4.2.1-1. Three additional scleractinian taxa (*Lobophyllia, Oulophyllia, Fungia*) not seen in belt transects were observed in the larger area around the transects at the single site surveyed at Aguijan. Four genera (*Goniastrea, Pavona, Porites, and Sinularia*) each contributed more than 10% of the total number of colonies enumerated.

Table D.4.2.1-1. Number of cnidarians surveyed in belt transects at Aguijan in 2007. Taxa contributing more than 10% of the total number of coral colonies are in bold.

Genus	# colonies	% of total
Coscinaraea	5	2.2
Favia	16	7.1
Galaxea	1	0.4
Gardineroseris	3	1.3
Goniastrea	41	**18.1**
Heliopora	1	0.4
Leptastrea	2	0.9
Lobophytum	5	2.2
Montastrea	2	0.9
Palythoa	1	0.4
Pavona	32	**14.2**
Platygyra	3	1.3
Pocillopora	2	0.9
Porites	36	**15.9**
Psammocora	5	2.2
Sinularia	52	**23.0**
Stylophora	19	8.4
Total # colonies	1307	100.0
Area surveyed, m^2	500	

Size Class Structure

A size class distribution of all cnidarians enumerated within belt transects at Aguijan in 2007 is shown in Figure D.4.2.1-1. The majority (73.0%) of cnidarians were small, with a maximum estimated diameter of less than 10 cm.

D.4.2.2 Percent Benthic Cover

In 2007, percent benthic cover surveys were conducted at one REA site in Aguijan. Patterns of percent benthic cover for that site are presented in Figure D.4.2.2-1. Mean percent live coral cover for site AGU-3 was a low 7.8%. Scleractinian genera enumerated the point-count transects of *Favia*, *Gardineroseris planulata*, *Pocillopora*, and *Porites*.

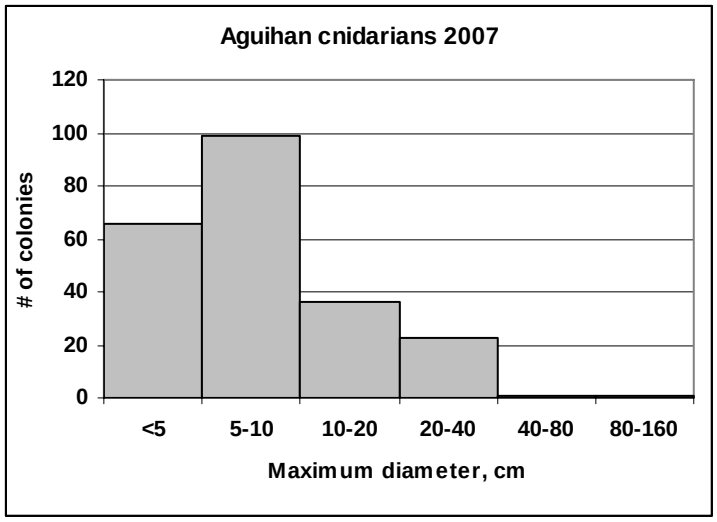

Figure D.4.2.1-1. Size class distributions of cnidarians enumerated in belt transects at Aguijan in 2007.

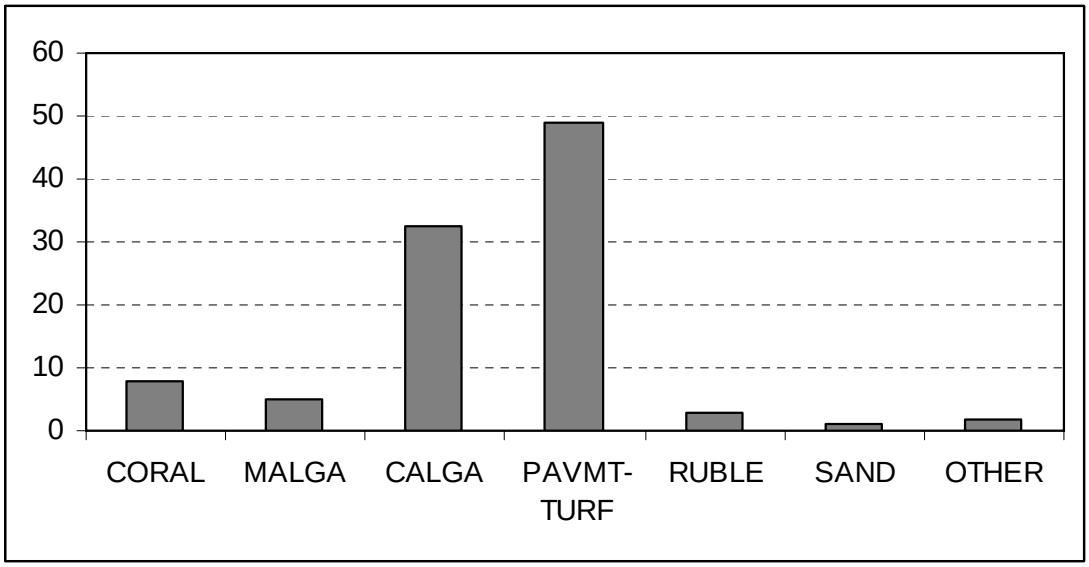

Figure D.4.2.2-1 Mean percent cover of selected benthic elements derived from 1 REA survey at Aguijan Island, MAR-RAMP 2007. CORAL: live scleractinian and hydrozoan stony corals; MALGA: fleshy macroalgae; CALGA: crustose coralline algae; PAVMT-TURF: turf-algae covered carbonate pavement; RUBLE: coral rubble (including recent and old coral rubble covered with turf-algae); SAND: sand; and OTHER: other sessile invertebrates including alcynoarian corals, echinoderms, sponges, tunicates, as well as cyanobacterial mats.

D.4.2.3 Coral Disease

Within the survey area (300 m^2) at site AGU-3, two cases of white syndrome on *Gardineroseris planulata*, as well as one case of cyanobacterial infection on *G. planulata*. Additionally, 30 cases of coralline lethal orange disease were enumerated.

D.4.2.4 Benthic Towed-diver Surveys – Corals

The average hard coral cover for Aguijan was recorded at 12% (range 1.1–30%), with stressed coral averaging 8% (range 0–20%). The highest average coral cover (average 14%, range 5.1–20%) was noted along the southern coast, where the terrain consisted of rock flats. The flats gave way to patch reef in sand and after 10 minutes turned back into pavement, which ended the survey. An increase in *acroporiids* was noticed in segment 5.

The highest coral stress (average 11%, range 5.1–20%) was noted along the western coast of the island during a survey which progressed from the northwestern corner to the southwestern corner. No additional information was noted during the surveys regarding stressor sources.

The average soft coral cover for Aguijan was 7% (range 0.1–30%). The highest overall soft coral cover was recorded during the western-most survey moving from the northwestern corner to the southwestern corner (average 9%, range 1.1–20%).

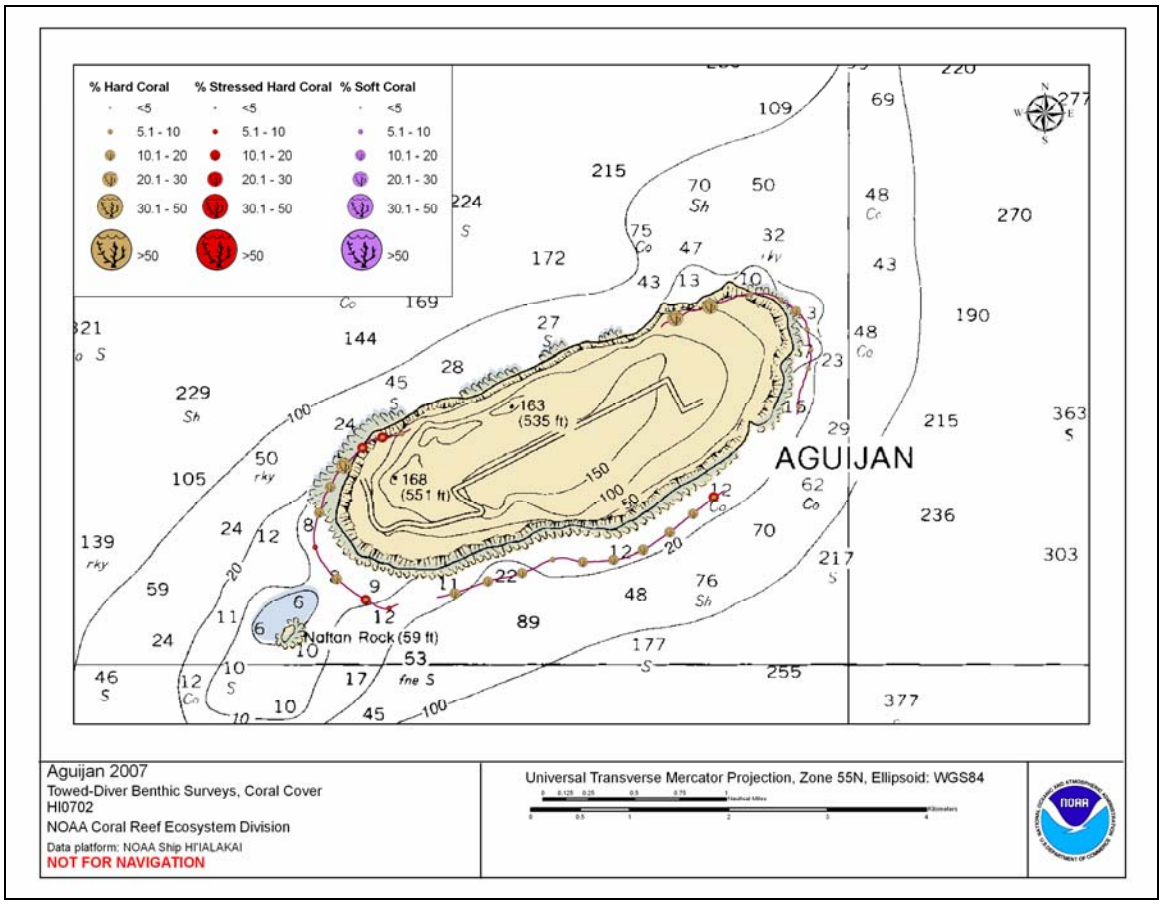

Figure D.4.2.4-1: Overall hard coral, stressed coral, and soft cover around Aguijan (2007).

D.4.3 Macroinvertebrates

D.4.3.1 Benthic Towed-diver Surveys — Macroinvertebrates

The overall macroinvertebrate averages per survey for Aguijan Island were 0.4 COTs, 16.8 sea urchins, 42.9 sea cucumbers, and 1.6 giant clams. The majority of COTs were observed on the west side of the island, where seven individuals were counted during the entire survey. The presence of COTS coincides with the highest level of stressed hard corals, averaging as high as 20% per 5-minute segment. Sea urchin numbers remained low for the majority of surveys, the most being counted along the pavement flats on the south side of the island, where 414 individuals were observed. Sea cucumber presence was heavy along the east side of the island, where the habitat was predominantly a moderate reef slope of pavement. Nine hundred forty-one individuals were recorded during the entire survey, with a survey average of 124.1 individuals per five-minute segment. Additionally, giant clams were most often observed along the west and south sides of Aguijan. The majority occurred along the southern end of the island, where 28 individuals were recorded during the 50-minute survey.

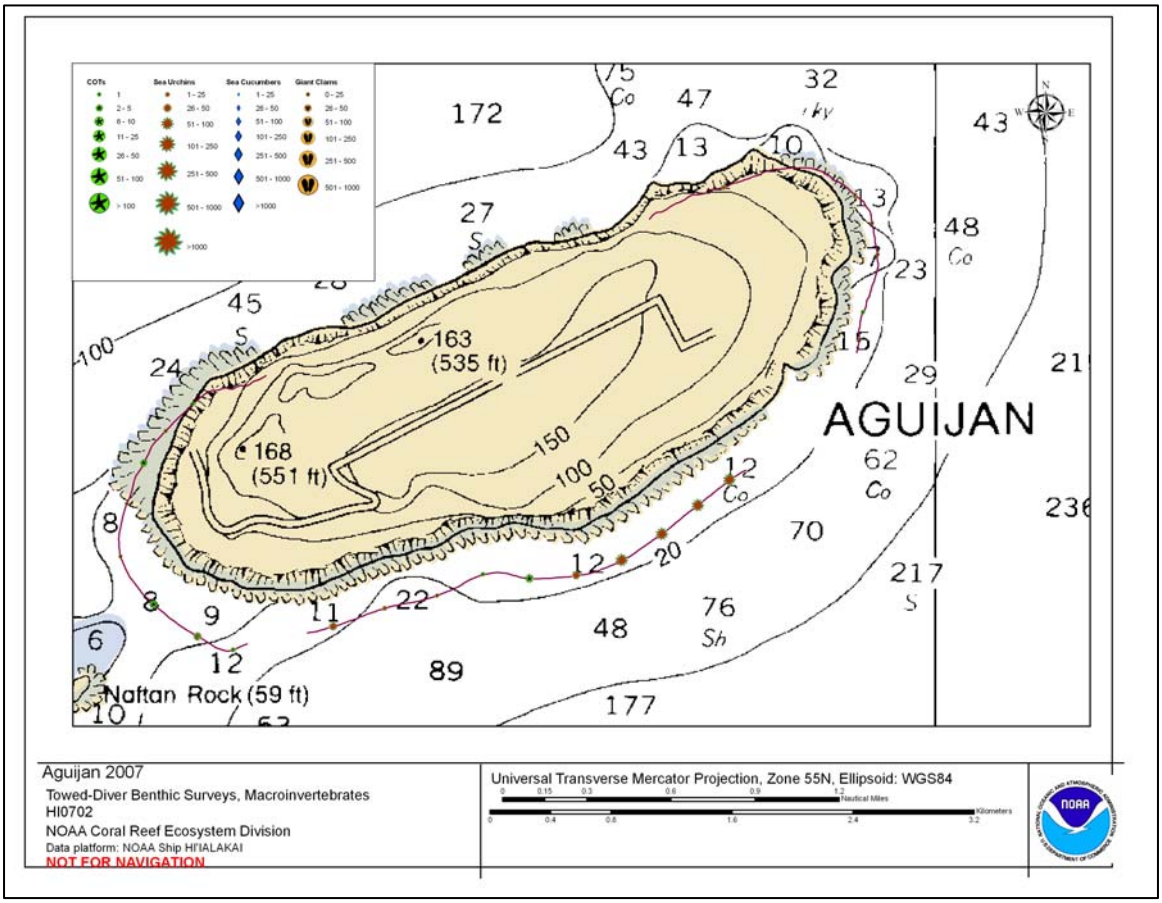

Figure D.4.3.1-1 Towed-diver macroinvertebrate observations at Aguijan for HI-07-02.

D.4.3.2 Invertebrate Collections

Acanthaster planci was collected at one location around Aguijan:

Location	Date	Collector	Species	# of Samples	REA site	Site location	Habitat	Depth-ft	Lat deg	Lat min	Lon deg	Lon min
Aguijan	5/18/2007	Allison Palmer	*Acanthaster planci*	1	AGU-3	NW Side	Forereef	45	14	51.5830	145	33.3590

D.5. Fish

D.5.1 REA Fish Surveys

Stationary Point Count data

A total of four individual SPC surveys were conducted at one forereef site around the island of Aguijan. Divers enumerated fishes from 6 families and 12 species during the survey period. Parrotfishes (Scaridae) were the most abundant family and the largest contributor to biomass with 0.111 ton per hectare. Snappers (Lutjanidae), wrasses

(Labridae), and rabbitfish (Siganidae) were also commonly observed during the SPCs yielding biomasses of 0.014, 0.008, and 0.008 ton per hectare, respectively.

Belt-Transect data

During the survey period, three belt-transect surveys were conducted at one forereef site around the island of Aguijan. Divers enumerated fishes from 14 families and 42 species during surveys. Damsels (Pomacentrids) were the most abundant fishes, but did not significantly contribute to the overall biomass (0.010 ton per hectare). Surgeonfish were the second most abundant family and the largest contributor to biomass with 0.102 ton per hectare. Puffers (Tetraodontidae), while not abundant, were the second largest contributor to biomass with 0.031 ton per hectare. Parrotfish (Scarids) contributed 0.019 ton per hectare (Fig. D.5.1-1).

Overall observations

A total of 91 species from 23 families were observed during the survey period by all divers. The medium to large fish biomass at the site in Aguijan during the survey period was 0.15 ton/ha for the SPC surveys (Table D.5.1-1), and the total fish biomass was 0.19 ton/ha for the Belt transect surveys (Table D.5.1-2).

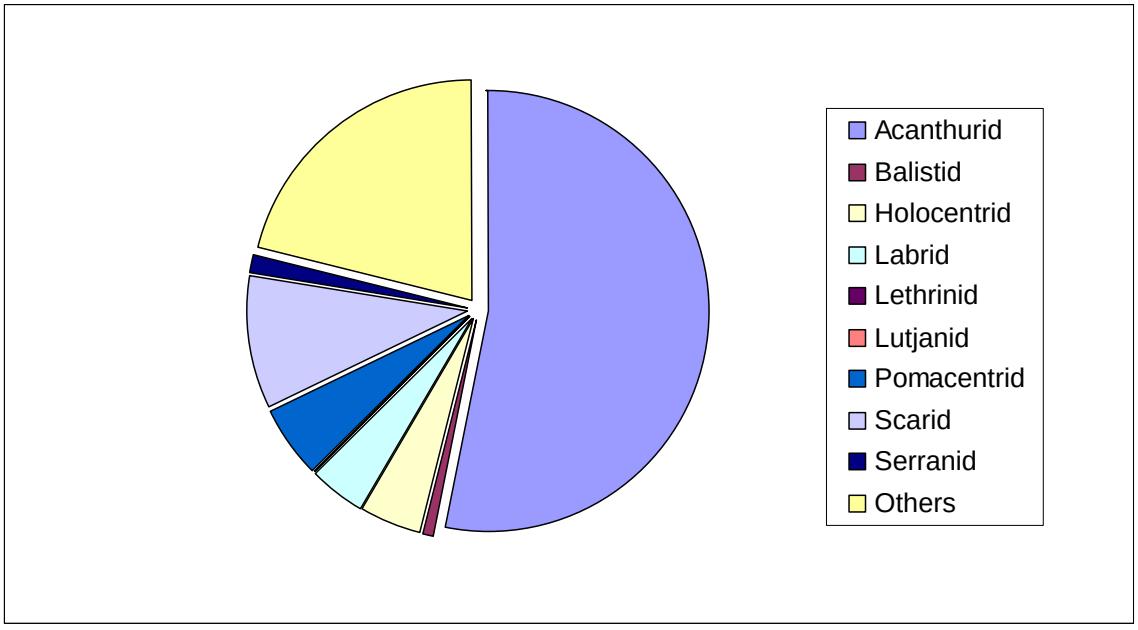

Figure D.5.1-1 – Family composition of the total fish biomass (0.19 ton per hectare) around the island of Aguijan.

Table D.5.1-1. Average medium to large fish biomass (tail length >25 cm) around the island of Aguijan (ton per hectare).

Site	Total	Labrid	Lethrinid	Lutjanid	Scarid	Serranid	Siganid
AGU-3	0.15	0.008	0.007	0.014	0.111	0.004	0.008

Table D.5.1-2. Total fish biomass around the island of Aguijan (ton per hectare).

Site	Total	Acanthurid	Holocentrid	Labrid	Pomacentrid	Scarid	Tetraodontid	Others
AGU-3	0.19	0.102	0.009	0.008	0.010	0.019	0.031	0.014

D.5.2 Fish Towed-diver Surveys

At Aguijan, the Towboard team conducted three tows totaling 8.4 kilometers in length and covering 8.4 hectares of ocean bottom. Mean survey length was 2.8 km. Fifteen fish (>50 cm TL, all species spooled) were observed totaling 10 different species. Overall, numeric density was 1.78 fish per hectare. Blacktip reef sharks (*Carcharhinus melanopterus*), twinspot snapper (*Lutjanus bohar*), green jobfish (*Aprion virescens*), dogtooth tuna (*Gymnosarda unicolor*), and a marble ray (*Taeniura meyeni*) were the five most commonly observed species (>50 cm TL) at Aguijan during the survey period (Table D.5.2-1).

Table D.5.2-1. Total number of individuals of each species observed at Aguijan.

Island	Taxon Name	#
Aguijan	Carcharhinus melanopterus	4
	Lutjanus bohar	2
	Aprion virescens	2
	Gymnosarda unicolor	2
	Taeniura meyeni	1
	Diodon hystrix	1
	Aetobatus narinari	1
	Caranx melampygus	1
	Scomberoides lysan	1
Aguijan Total		15

Appendix E: Tinian

E.1. Benthic Habitat Mapping

During HI-07-02 multibeam mapping surveys were conducted at Tinian Island using the *Hi'ialakai's* EM300 and the R/V *AHI's* multibeam sonars. The *Hi'ialakai* spent 2 days and 2 nights mapping around Tinian. The *AHI* returned to Tinian Harbor from Saipan on May 23 while the ship was in port at Saipan Harbor. During the first day of operations for HI-07-03, the ship escorted the *AHI* and other small boats to Tinian for one more day of work. Total coverage by the *Hi'ialakai* at Saipan, Tinian, and Aguijan, combined, was ~1,800 sq. km within water depths ranging between 14 and 2,800 m (Fig. E.1-1). The *AHI* added ~23 sq. km of multibeam data at Tinian around the 100 fm contour and in the anchorage area outside the Tinian Harbor (Fig. E.1-2).

Prior to HI-07-02 multibeam data were collected by the *AHI* in 2003, covering a large portion of the bank top of Tinian to depths of ~300 m. During the cruise, the *Hi'ialakai* extended the multibeam maps to depths reaching ~1,800 m on the east and south sides and ~1,000 m on the west side. Tinian Island is surrounded by a bank that connects to the bank around Saipan. It extends off the east side of the island, also following a few deep canyons. From the point off the middle of the east side of the island, the slope is more gradual. Another gradual submerged peninsula-shaped structure extends just south of there. Off the southeastern tip of Tinian lies submerged Tatsumi Bank, rising to the shallow depth of ~5 m with a gradual slope surrounding it. The seafloor connects to Aguijan, via a submerged ridge, from the southwest tip of Tinian. The west side of the island gradually extends to deeper depths with only one canyon leading off from the center of the west side. During the last day at Tinian, the *AHI* was able to circumnavigate from the northeastern tip heading south around the south point to the Tinian anchorage/harbor area. This last pass filled in the remaining gap of data along the 100-fm contour between 2003 *AHI* coverage and *Hi'ialakai* coverage. The survey launch also filled in several gaps in shallow data across the anchorage where the U.S. Navy is considering sites for pre-positioned ships.

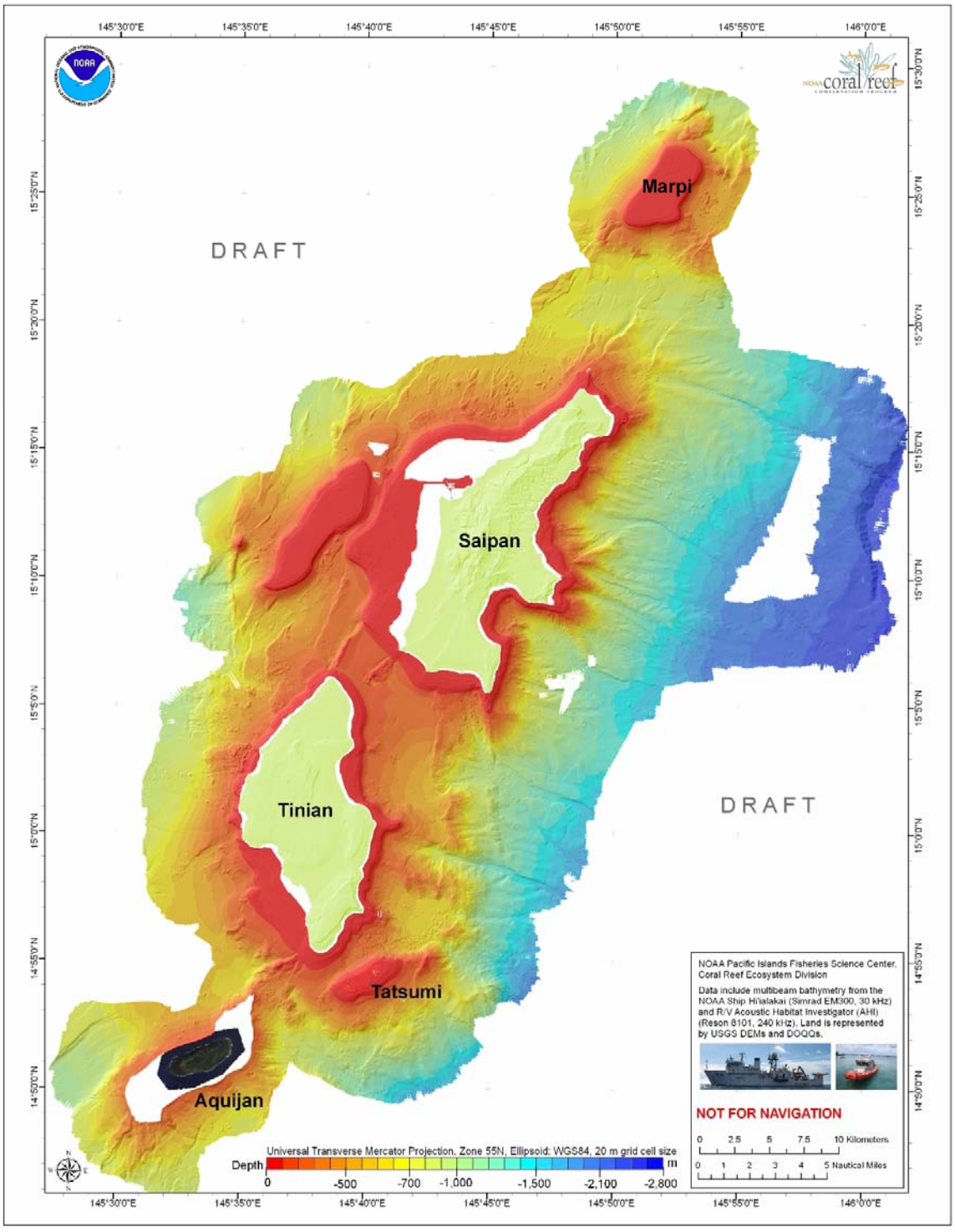

Figure E.1-1: Multibeam bathymetry of Tinian and Saipan, shown with a USGS DEM, and of Aguijan, with a USGS Digital Orthophoto Quadrangle Image.

The R/V *AHI* worked in Tinian Harbor with representatives from NOAA's Office of Coast Survey (OCS) to complete nautical charting surveys of the harbor. During 1 day of surveying, they completed multibeam mapping as well as sidescan surveys of the entire harbor. The data from the *AHI* surveys will be processed by OCS and used for nautical chart updates by the end of 2007. A final summary of mapping survey results from the R/V *AHI* will be presented in a separate report.

E.2. Oceanography and Water Quality

In total, one instrument was recovered and two instruments were deployed at Tinian during HI-07-02. One subsurface temperature recorder (STR) was recovered and replaced, colocated with REA 1 on the east side of the island, and one new STR was deployed on the northwest side of the island colocated with REA 6 (Fig. E.2-1).

Twenty-six shallow water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Tinian at approximately 1 mile intervals following the 30-m contour. At four of these CTD locations, water sample profiles were performed concurrently, using a daisy chain of Niskin bottles at 1 m, 10 m, 20 m and 30 m depths, and at one CTD location in a shallow bay a water sample was performed at 1m only, for a total of 34 discrete water samples measuring chlorophyll and nutrient concentrations.

In situ temperature data obtained from October 2005 to May 2007 shows seasonal variability with warm temperatures observed from July to November and cooler temperatures from January to April (Fig. E.2-2). In situ data are approximately 0.5- °C warmer than the climatological average from November 2005 to July 2006. This is followed by a short period warm event during September/October 2006 when temperature was ~0.5–0.7 °C above the climatological mean, reaching a maximum of 30.1 °C. Subsequent to this warm period, and for the remainder of the time series, the in situ data follows the climatology rather closely.

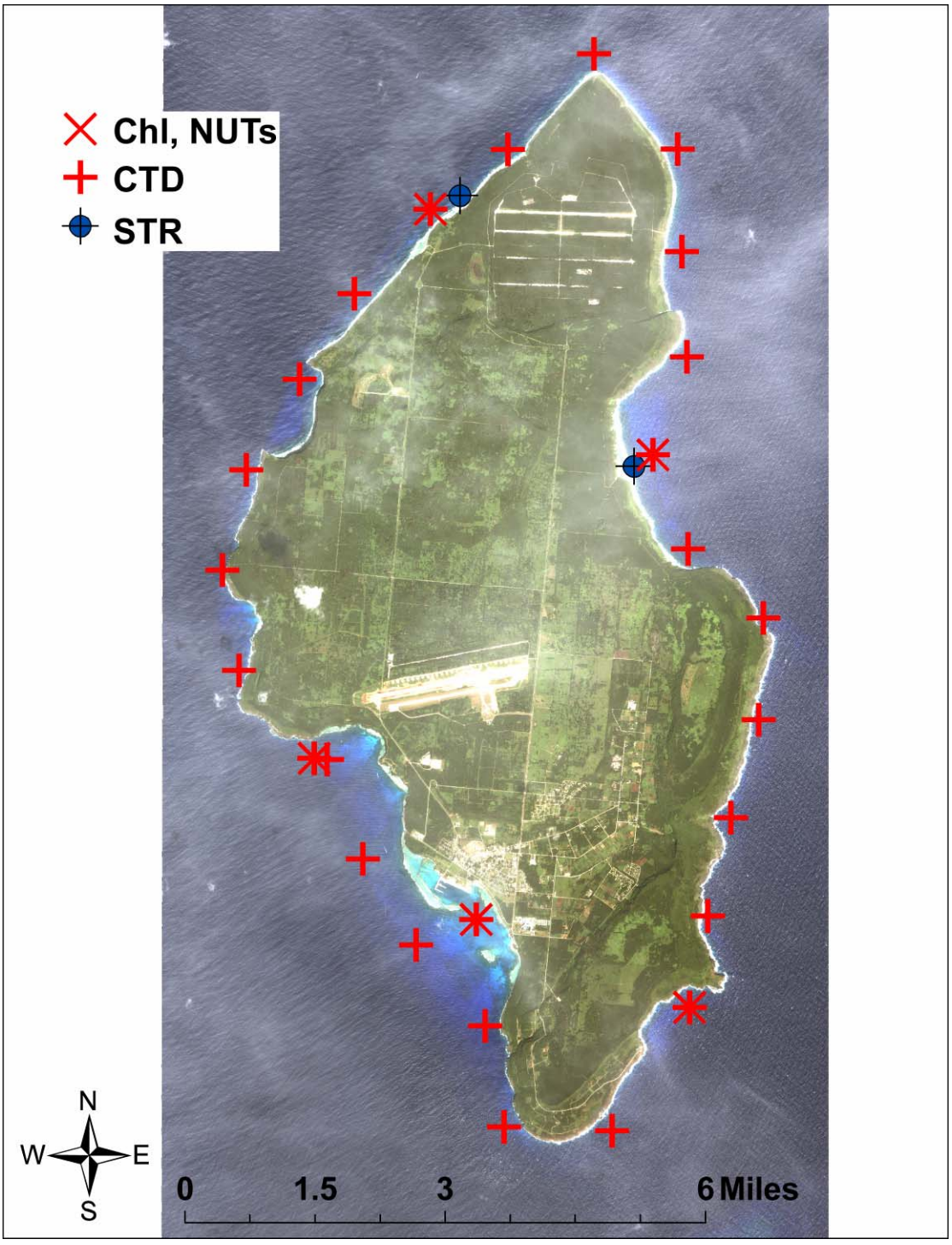

Figure E.2-1. Positions of CTDs, water samples, and moorings at Tinian.

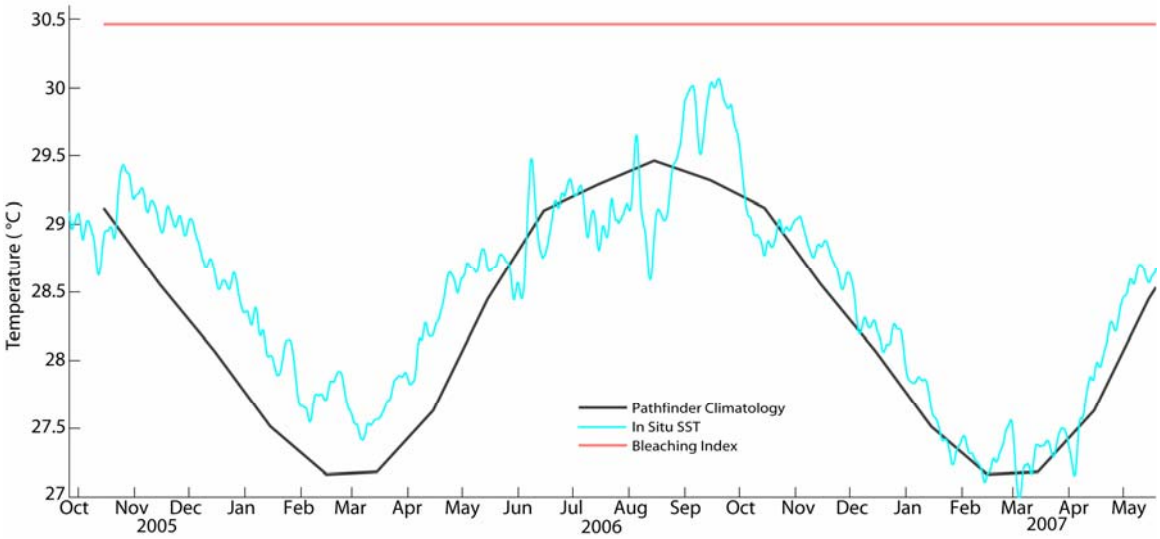

Figure E.2-2: In situ temperature time series from Tinian overlaid with Pathfinder SST climatology, and including the coral reef bleaching index.

E.3 Rapid Ecological Assessment (REA) Site Descriptions

Tinian: Fishing pressure is moderate; mostly coming from Saipan-based fishing companies. Cast netting, spear fishing, hook and line, gleaning, trolling and bottom fishing are all common fishing practices in Tinian. A local government draft proposal is pending for the establishment of a marine protected area around Tinian.

REA surveys were conducted at four sites at Tinian (Table E.3-1). The locations of the REA sites at Tinian is shown in Figure E.3-1.

Table E.3-1. Sites surveyed by REA team at Tinian, HI-07-02, May 2007. Depths and temperature are from Kenyon's dive gauge.

Site #	Date	Latitude (north)		Longitude (east)		Transect depth range, m	Max. depth, m	Temp, °C
TIN-2	5/18/07	14	56.418	145	37.677	12.1- 13.9	19.1	28.9
TIN-3	5/19/07	14	59.429	145	36.174	11.8 - 12.7	13.9	28.3
TIN-6	5/19/07	15	4.825	145	37.271	10.9 - 12.7	20.3	28.3
TIN-1	5/19/07	15	2.100	145	39.087	12.7 - 13.9	16.7	28.3
TIN-4	5/25/07	14	56.860	145	39.791	11 - 12	14.6	28.3

Figure E.3-1. Location of 2007 REA survey sites at Tinian.

TIN-2
May 18, 2007
Southwest side, transect depth 40–46 ft. Somewhat scoured appearance. Fifteen genera of scleractinian corals, one octocoral genus, two hydrozoan (*Heliopora* and *Millepora*) and one other hexacoral (*Zoanthus*) enumerated within 50 m^2. Four additional genera (*Oulophyllia*, *Coscinaraea*, *Gardineroseris*, *Acropora*) seen outside belt transects. Scoured bottom, low percent live coral cover (8.8%). Pavement covered on turf-algae comprised over 66% of benthic cover. Disease surveys report that, within the survey area (180 m^2), one case of bleaching and discoloration was observed on *Astreopora* sp. In addition, seven cases of coralline discoloration and eight cases of coralline lethal orange disease were enumerated. The algae survey showed very little diversity within the transect area. Crustose coralline algae and blue-greens were present. No other species were collected during the random swim.

TIN-3
May 19, 2007
West side, transect depth 39–42 ft. Dominated by helmet-shaped *Porites* colonies and *Porites rus*. Twelve genera of scleractinian corals and one octocoral genus enumerated within 50 m^2. Five additional genera (*Turbinaria, Lobophyllia, Galaxea*, *Stylophora,* and *Psammocora*) seen outside belt transects. Important *Porites rus* buildups; percent live coral cover was moderately high (31.4%). Pavement covered on turf-algae comprised over 49% of benthic cover. Disease surveys report that, within the survey area (325 m^2), the following disease states were observed on *Porites*: one case of bleaching, one case of tissue loss, two cases of skeletal growth anomalies and eight cases of pink irritations and other coral-algal interactions. In addition, eight cases of coralline lethal orange disease were enumerated. The algae survey was conducted on a transect site that was mostly covered by *Porites* corals. Crustose corallines, *Halimeda* spp. and *Amphiroa fragilissima* were the dominant algae. Several other species were collected during the random swim including *Tydemania expeditionis, Avrainvaillea lacerata*, *Halimeda macroloba, Peyssonnelia inamoena*, and *Dichotomaria marginata*.

TIN-6
May 19, 2007
Northwest side, transect depth 36–42 ft. Carbonate outcrops and sand channels. Twenty-one genera of scleractinian corals and one octocoral genus enumerated within 50 m^2. Two additional genera (*Lobophytum, Plesiastrea)* seen outside belt transects. *Acropora palifera* common. Moderately low percent live coral cover (13.7%). Pavement covered on turf-algae comprised over 35% of benthic cover. Disease surveys report that, within the survey area (300 m^2), two cases of bleaching were observed on *Porites* and *Goniastrea*, respectively; and one case of white syndrome was observed on *Porites*. The algae at this site were composed mainly of *Halimeda* spp. with a few turfs such as *Gelidiella* spp., *Amphiroa fragilissima, Dichotomaria marginata, and Galaxaura cohaerens*. Crustose coralline algae were also present. *Chlorodesmis hildebrandtii, Portieria hornemanii, Turbinaria conoides, Peyssonnelia inamoena,* and *Mastophora rosea* were collected during the random swim.

TIN-1
May 19, 2007
East side, transect depth 42–46 ft. Moderately high relief eroded carbonate. Twenty-three genera of scleractinian corals and two octocoral genera enumerated within 50 m^2. No additional genera seen outside belt transects. Scoured bottom, low percent live coral cover (6.9%). Pavement covered on turf-algae comprised nearly 55% of benthic cover, and macro-algae accounted for 21% of the bottom cover. Disease surveys report that, within the survey area (375 m^2), one case of bleaching was observed on *Porites*, as well as three cases of *Porites* pink irritations and coral-algal interactions. In addition, one case of coralline lethal orange disease was detected. This algae community located on a gradual slope was the most diverse seen on Tinian with at least 10 genera represented within the transect area. *Halimeda* spp., *Caulerpa* spp., several epiphytic algae, *Dichotomaria marginata, Galaxaura cohaerens, Dictyota* spp., *Asparagopsis taxiformis, Neomeris* spp., *Turbinaria* spp., and *Jania capillacea* were found.

TIN-4
May 25, 2007
Windward South side, transect depth range: 33–36 ft. Forereef with large boulders on the southeastern end of the island. Aggregate relief, carbonate boulders, rubble, and sand; low percent live coral cover (5.9%). Pavement covered on turf-algae comprised over 55% of benthic cover, and calcareous encrusting red algae and coralline algae accounted for over 13% of the live benthis. Within the survey area (300 m^2), one case of *Porites* discoloration, as well as three cases of coralline orange lethal disease and six cases of calcareous algae discoloration were observed. In addition, five cases of *Acanthaster* predation were detected. On both transects *Halimeda* spp. were the most predominant macroalgae. The two most common *Halimeda* species are *H. taenicola* and *H. tuna*. Other algal categories collected on the transects: *Dictyota, Jania, Neomeris,* cyanobacteria, and encrusting Corallines. Species collected haphazardly included *Actinotrichia fragilis, Chrysocystis* (forming small patches), *Caulerpa filicoides* (sides of the boulders), *Dichotomaria marginata* (dispersed clumps), *Galaxaura rugosa* (gametophyte), *Halimeda taenicola, Melanamansia, Microdictyon*, and *Ventricaria ventricosa*. Corallines were especially abundant at this site.

E.4. Benthic Environment

E.4.1. Algae

Tentatively for Guam and the southern CNMI, 45 macroalgae genera were found altogether: 37 known species (16 genera) of green algae (Chlorophyceae), 28 known species (25 genera) of red algae (Rhodophyceae), and 6 known species (4 genera) of brown algae (Phaeophyceae). Also, several unidentified species of filamentous algae were grouped into the functional category of turf algae, and multiple species of cyanobacteria were found. Turf and calcified algae seem to do well on these wave-scoured islands. Subsequent to microscopic examination of samples, it is expected that with the identification of epiphytes and several species of macroalgae the number of species collected will increase substantially. Quantitative sites were all situated in depths of about 35-55 ft, mostly around 40 ft. A comprehensive algae list is shown below in Table E.4.1-1. Further examination of species is needed to increase accuracy and complete the list.

Table E.4.1-1. List of putative algae species in the southern Mariana Islands: Guam, Rota, Aguijan, Tinian, and Saipan.

Green algae	**Red algae**
Avrainvaillea erecta	*Amphiroa fragillissima*
Avrainvaillea lacerate	*Actinotrichia* sp.
Boergesenia forbesii	*Asparagopsis taxiformis*
Boodlea vanbosseae	*Botryocladia skottsbergii*
Bornetella oligospora	*Botryocladia tenuissima*

Green algae	**Red algae**
Bryopsis pennata	*Crouania* sp.
Caulerpa biserrulata	*Dichotomaria marginata*
Caulerpa cupressoides	*Galaxaura cohaerens*
Caulerpa elongata	*Gelidiella acerosa*
Caulerpa filicoides var. *andamanensis*	*Gelidiella pannosa*
Caulerpa geminata	*Gelidiopsis* sp.
Caulerpa nummularia	*Gibsmithia dotyi*
Caulerpa spp.	*Gibsmithia hawaiiensis*
Caulerpa racemosa var. *lamourouxii*	*Halymenia dilatata*
Caulerpa sertularioides	*Haloplegma duperreyi*
Caulerpa serrulata	*Jania capillacea*
Caulerpa taxifolia	*Liagora* sp.
Caulerpa webbiana	*Lobophora variegata*
Chlorodesmis hildebrandtii	*Mastophora rosea*
Codium bulbopilum	*Mesophyllum funagutiense*
Dictyosphaeria cavernosa	*Neurymenia fraxinifolia*
Dictyosphaeria versluysii	*Peyssonnelia inamoena*
Halimeda cuneata	*Platoma* cf. *ardreanum*
Halimeda cf. *discoidea*	*Portieria harveyi*
Halimeda lacunalis f. lata	*Portieria hornemannii*
Halimeda macroloba	*Predaea weldii*
Halimeda macrophysa	*Tolypocladia calodictyon*
Halimeda minima	*Tricleocarpa fragilis*
Halimeda opuntia	UNK SP. 1
Halimeda spp.	UNK SP. 2
Microdictyon setchellianum	UNK SP. 3 (UNK Sp. 2)
Neomeris van-bosseae	UNK SP. 4-red epiphyte
Neomeris spp.	**Brown algae**
Rhipiliopsis sp.	*Dictyota ceylanica*
Tydemania expeditionis	*Dictyota bartayresiana*
Valonia fastigiata	*Hydroclathrus clathrata*
Ventricaria ventricosa	*Padina boergesenii*
Unk. Species	*Turbinaria conoides*
Green mat/fuzz (Unk sp. 1)	*Turbinaria ornate*
Functional groups	
Blue-green	
Turf	
CCA	

Time constraints prevented resurvey of the 2005 site TIN-05 on the southwest side of the island. Most of the sites appeared to be heavily scoured by wave action. Algal communities were mostly dominated by crustose corallines, *Halimeda* spp. and blue-greens. The most diverse algal community was found at site TIN-01 on the northeast side of the island. Table E.4.1-2 below shows relative abundance of algal species.

Table E.4.1-2: Algal taxa or functional groups recorded in photoquadrats by site at Tinian. First row of numbers indicates the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat.

	TIN-02	TIN-03	TIN-06	TIN-01	TIN-04
GREEN ALGAE					
Avrainvaillea lacerata	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**4.0**	**0.0**	**0.0**
Caulerpa filicoides var. *andamanensis*	0.0	0.0	0.0	25.0	0.0
	0.0	**0.0**	**0.0**	**4.3**	**0.0**
Caulerpa serrulata	0.0	0.0	0.0	8.3	0.0
	0.0	**0.0**	**0.0**	**5.0**	**0.0**
Halimeda lacunalis f. lata	0.0	0.0	0.0	0.0	8.3
	0.0	**0.0**	**0.0**	**0.0**	**2.0**
Halimeda opuntia	0.0	0.0	25.0	0.0	0.0
	0.0	**0.0**	**1.0**	**0.0**	**0.0**
Halimeda spp.	50.0	33.3	58.3	91.7	66.7
	1.3	**2.4**	**1.8**	**1.0**	**1.8**
Microdictyon setchellianum	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**
Neomeris van-bosseae	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**
Neomeris spp.	0.0	8.3	0.0	25.0	8.3
	0.0	**3.0**	**0.0**	**5.7**	**9.0**
Ventricaria ventricosa	0.0	0.0	0.0	0.0	0.0
	5.0	**0.0**	**0.0**	**0.0**	**0.0**
RED ALGAE					
Amphiroa fragillissima	58.3	91.7	33.3	0.0	8.3
	2.9	**2.4**	**2.6**	**0.0**	**9.0**
Asparagopsis taxiformis	0.0	0.0	25.0	25.0	0.0
	0.0	**0.0**	**2.3**	**3.7**	**0.0**
Crouania sp.	0.0	0.0	0.0	33.3	0.0

	TIN-02	TIN-03	TIN-06	TIN-01	TIN-04
	0.0	**0.0**	**0.0**	**4.5**	**0.0**
Dichotomaria marginata	0.0	0.0	16.7	25.0	0.0
	0.0	**0.0**	**5.0**	**2.3**	**0.0**
Galaxaura cohaerens	0.0	0.0	41.7	25.0	8.3
	0.0	**0.0**	**2.6**	**3.3**	**4.0**
Gelidiella acerosa	0.0	0.0	16.7	0.0	0.0
	0.0	**0.0**	**7.0**	**0.0**	**0.0**
Gelidiella pannosa	0.0	8.3	50.0	0.0	0.0
	4.0	**4.0**	**4.3**	**0.0**	**0.0**
Jania capillacea	8.3	0.0	8.3	8.3	8.3
	5.0	**0.0**	**7.0**	**7.5**	**7.0**
Mastophora rosea	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**5.0**	**0.0**	**0.0**
Portieria harveyi	0.0	0.0	0.0	8.3	0.0
	0.0	**0.0**	**0.0**	**3.0**	**0.0**
Portieria hornemannii	0.0	0.0	0.0	8.3	0.0
	0.0	**0.0**	**0.0**	**5.0**	**0.0**
Predaea weldii	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**
Tolypocladia calodictyon	0.0	0.0	8.3	8.3	0.0
	0.0	**0.0**	**1.0**	**5.0**	**0.0**
UNK SP. 4	0.0	0.0	0.0	41.7	0.0
	0.0	**0.0**	**0.0**	**4.4**	**0.0**
BROWN ALGAE					
Dictyota ceylanica	0.0	8.3	0.0	25.0	0.0
	0.0	**4.0**	**0.0**	**5.5**	**0.0**
Turbinaria conoides	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**7.0**	**0.0**	**0.0**
FUNCTIONAL GROUPS					
Blue-green	66.7	75.0	66.7	83.3	50.0
	2.6	**2.0**	**2.9**	**4.1**	**3.0**
turf	25.0	16.7	50.0	58.3	91.7
	2.0	**3.5**	**3.7**	**3.3**	**1.8**
CCA	50.0	50.0	25.0	25.0	91.7
	2.2	**1.1**	**4.0**	**4.5**	**2.6**

E.4.1.2 BenthicTtowed-diver Surveys – Macroalgae

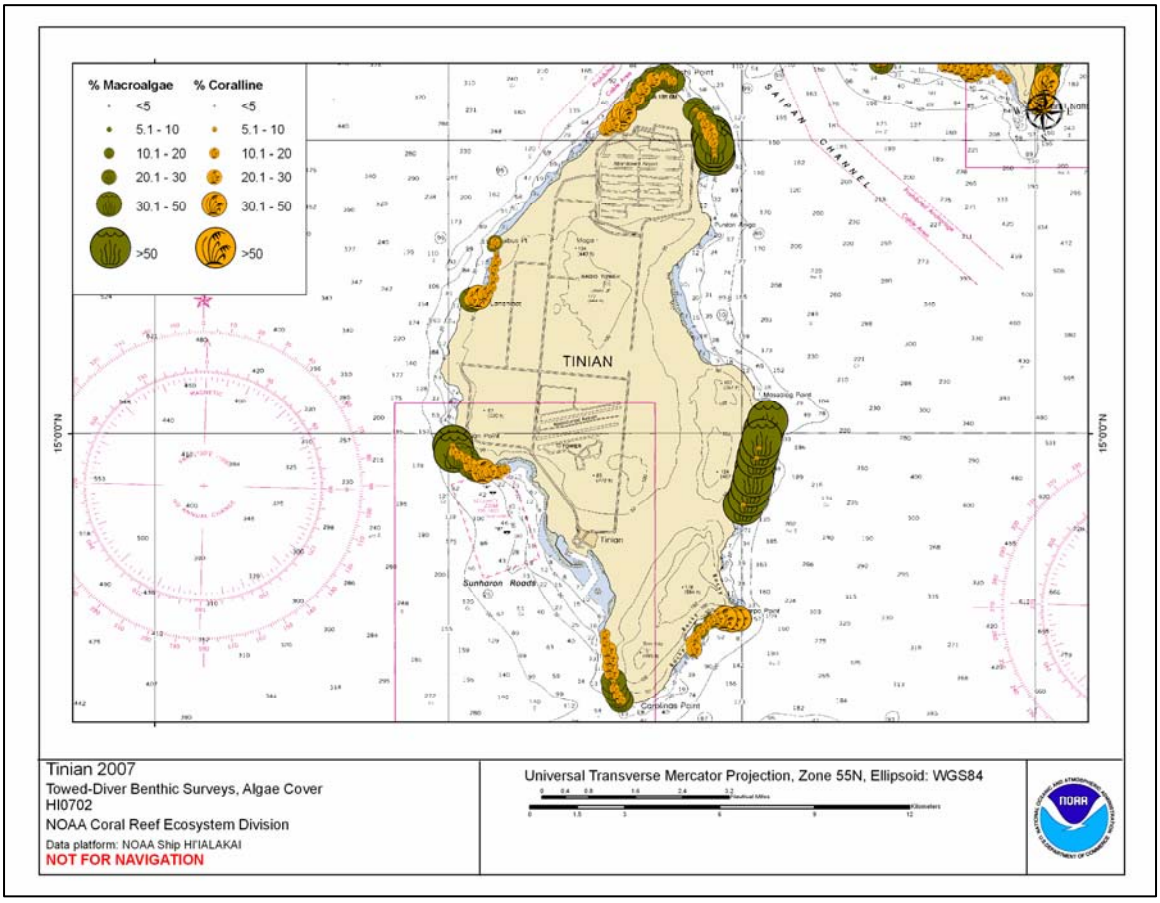

Figure E.4.1.2-1: Macroalgae and coralline algae cover around Tinian (2007).

The macroalgae and coralline algae cover at Tinian averaged 40% and 16% (range 5.1–100% and 1.1–40%, respectively). The highest macroalgae cover (average 76%, range 1.1–30%) was located along a 3.2-kilometer towed-diver survey ending near Massalog Point along the eastern shore. The area was characterized as a moderate slope reef with occasional rubble flats, rock slabs, clefts, crags, and pillars. Algae dominated the benthos, with several segments carpeted with 75.1–100% cover. *Halimeda*, *padina*, *liagora*, and *microdictyon* species were present. The highest coralline algae cover (average 25%, range 20.1–40%) was located near the northwest corner, rounding Ushi Point.

E.4.2. Corals

E.4.2.1 Coral Populations

Coral Diversity and Population Parameters

A total of 1,349 cnidarian colonies were enumerated within belt transects covering 200 m^2 at Tinian. These represented 29 cnidarian genera, of which 24 were scleractinian corals, two were octocorals (*Sinularia*, *Lobophytum*), two were hydrozoan (*Heliopora*

and Millepora), and one was an additional hexacoral (*Zoanthus*). The number of colonies enumerated and percentage of coral colonies represented by each taxon are shown in Table E.4.2.1-1. One additional scleractinian taxon (*Gardineroseris)* not seen in belt transects was observed in the larger area around the transects at one site surveyed at Tinian. Four genera (Favia, *Goniastrea, Leptastrea,* and *Porites*) each contributed more than 10% of the total number of colonies enumerated.

Table E.4.2.1-1. Number of cnidarians surveyed in belt transects at Tinian in 2007. Taxa contributing more than 10% of the total number of coral colonies are in bold.

Genus	# colonies	% of total
Acanthastrea	13	1.0
Acropora	32	2.4
Astreopora	118	8.7
Coscinaraea	3	0.2
Cycloseris	1	0.1
Cyphastrea	78	5.8
Favia	163	**12.1**
Galaxea	22	1.6
Goniastrea	211	**15.6**
Goniopora	1	0.1
Heliopora	1	0.1
Leptastrea	152	**11.3**
Lobophyllia	4	0.3
Lobophytum	3	0.2
Millepora	9	0.7
Montastrea	51	3.8
Montipora	17	1.3
Oulophyllia	4	0.3
Pavona	93	6.9
Platygyra	43	3.2
Plesiastrea	2	0.1
Pocillopora	28	2.1
Porites	210	**15.6**
Psammocora	20	1.5
Scapophyllia	1	0.1
Sinularia	24	1.8
Stylophora	17	1.3
Turbinaria	25	1.9
Zoanthus	3	0.2
Total # colonies	1349	
Area surveyed, m^2	200	

Size Class Structure

A size class distribution of all cnidarians enumerated within belt transects at Tinian in 2007 is shown in Figure E.4.2.1-1. The majority (82.4%) of cnidarians were small, with a maximum estimated diameter of less than 10 cm.

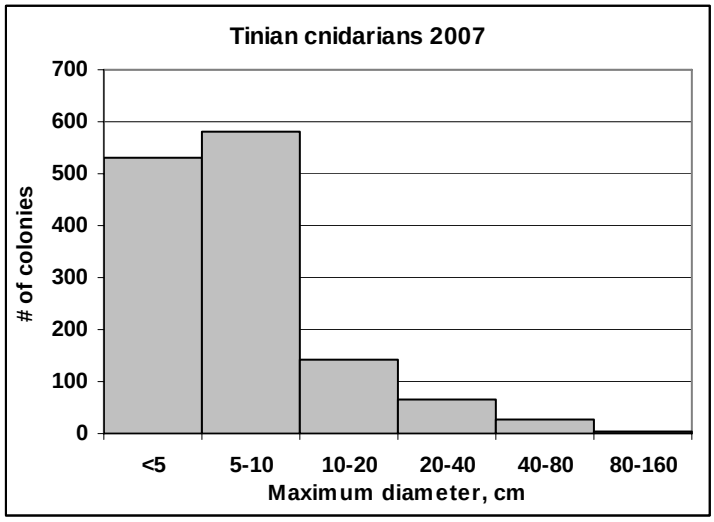

Figure E.4.2.1-1. Size class distributions of cnidarians enumerated in belt transects at Tinian in 2007.

E.4.2.2 Percent Benthic Cover

In 2007, percent benthic cover surveys around Tinian were conducted at five different sites. The line-intercept methodology quantified a total of 510 points along 250 m of forereef coral communities at depths ranging between 11 and 14 m. Patterns of intra-island variability in percent benthic cover are reflected in Figure E.4.2.2-1. Mean percent live coral cover for all sites combined was moderately low: 13.3 ± 4.5% (mean ± SE). Highest coral cover was recoded at site TIN-3 (31.4%) on the west-facing shore; low percent coral cover (5.9%) was encountered as sites TIN-4 on the southwest side of the island. Turf-algae covered carbonate pavement comprised over 50% of the benthic cover. A total of 12 scleractinian genera were enumerated along the point-count transects, with *Porites* being the most numerically abundant (33.4 ± 15.2%), followed by *Leptastrea* (16.3 ±.7.6%), and *Galaxea* (8.6%). Figure E.4.2.2-2 illustrates the contribution of the different scleractinain genera to the total percent live coral cover.

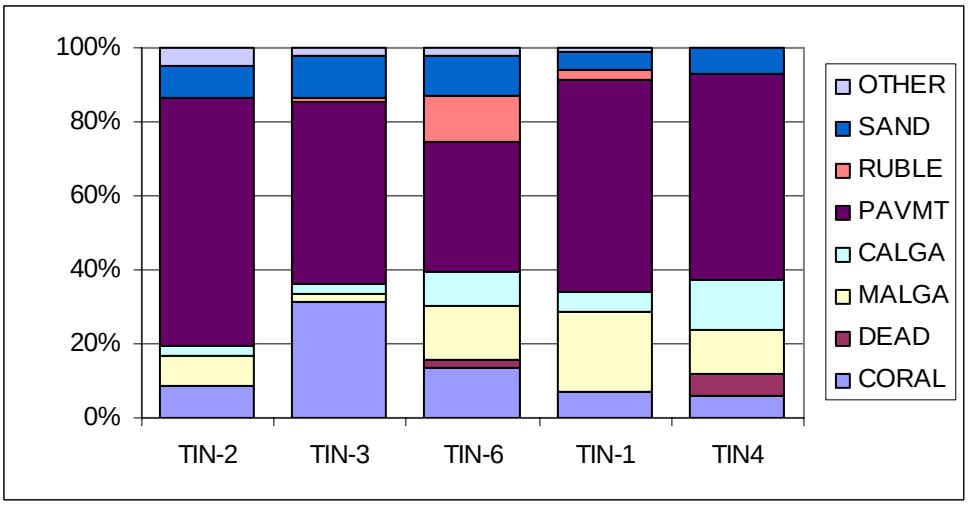

Figure E.4.2.2-1 Mean percent cover of selected benthic elements derived from five independent REA surveys at Tinian, MAR-RAMP 2007. CORAL: live scleractinian and hydrozoan stony corals; DEAD: dead coral; MALGA: fleshy macroalgae; CALGA: crustose coralline algae; PAVMT-TURF: turf-algae covered carbonate pavement; RUBLE: coral rubble (including recent and old coral rubble covered with turf-algae); SAND: sand; and OTHER: other sessile invertebrates including alcynoarian corals, echinoderms, sponges, tunicates, as well as cyanobacterial mats.

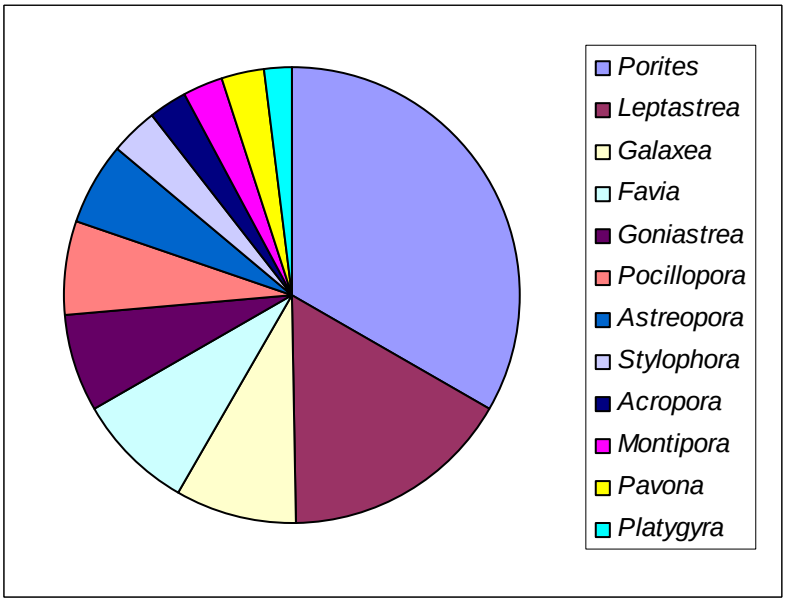

Figure E.4.2.2-2 Percent contribution of the different coral genera to the total live coral cover at Rota Island, MAR-RAMP 2007.

E.4.2.3 Coral Disease

In 2007, the coral disease REA surveyed a total area of ~1,439 m^2 at five different sites. A summary of disease occurrence is presented in Table E.4.2.3-1. Two main health conditions were observed in scleractinian corals: *Porites* pink irritations and other coral-algal interactions with pigmentation responses and discolorations other than bleaching (18.7%), and bleaching (7.8%). Coralline algal diseases and discolorations (CLOD and CBL) were also common, representing over 51% of cases. Predation scars by *Acanthaster* were also noted in relative high abundances.

Table E.4.2.3-1 Cumulative number of cases of disease conditions enumerated at each survey site around Tinian Island during the 2007 RAMP cruise. BLE: bleaching; PIR/IRR: *Porites* pink irritations and other coral-algal interactions with pigmentation responses; SGA: skeletal growth anomalies; WSY/TLS: white syndrome/tissue loss; OTH: 'other lesions' including *Porties* pink irritations and discolorations; CLOD: Coralline lethal orange disease; CBL: coralline algal discoloration. Total survey area ~1,430 m^2.

DZ/HS1	TIN-2	TIN-3	TIN-6	TIN-1	TIN4	Grand Total
BLE	1	1	2	1		5
SGA		2				2
WSY		1	1			2
OTH		6	2	3	1	16
PRE		3		2	5	6
CBL	8				6	14
CLOD	7	8		1	3	19
Grand Total	1	13	5	6	6	64

E.4.2.4 Benthic Towed-diver Surveys – Corals

The average hard coral cover for Tinian was recorded at 8% (range 0–30%), with stressed coral averaging 3% (range 1.1–30%). The highest average coral cover (average 17%, range 5.1–40%) was noted during the towed-diver survey along the west/northwest side from Puntan Lananibot to Faibus Point, where the terrain consisted of rolling reef with a light slope. Additional observations during this survey included increases in cyanobacteria observed during segments 5–7. During segment 8, large amounts of debris were observed along a section of barren pavement. The debris included airplane pars, vehicle parts, and many unidentifiable metals.

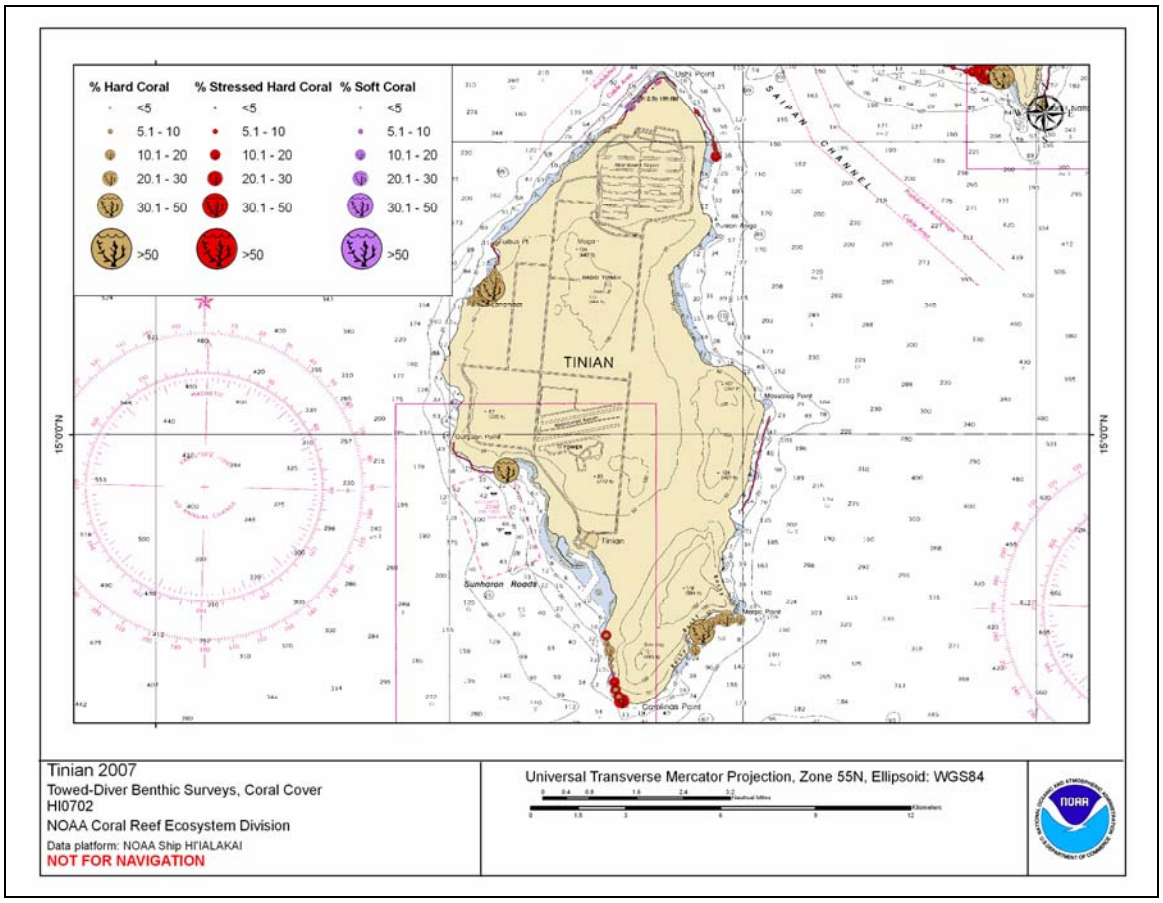

Figure E.4.2.4-1: Hard coral, stressed coral, and soft coral cover around Tinian (2007).

The highest average coral stress (average 12%, range 1.1–30%) was observed during a towed-diver survey along the north of Carolinas Point along the southwestern tip of Tinian. No additional information regarding coral stressors were noted during this survey.

The average soft coral cover for Tinian was 4% (range 0–20%). The highest overall soft coral cover was recorded during the towed-diver survey south of Marpo Point, along the southeastern corner of Tinian (average 9%, range 0.1–20%). Of particular note in the same area, an enormous *porites* colony (c.f. *lutea* or *lobata*) was noted at 13:41:42 of the survey (N14 56.678, E145 39.341). In addition, an estimated 15 x 250 lb bomb (unexploded ordinance) was noted at 14:00:00 (N14 56.308, E145 39.191), with a possible airplane (wheel) strut observed several minutes earlier.

E.4.3 Macroinvertebrates

E.4.3.1 Benthic Towed-diver Surveys - Macroinvertebrates

The overall macroinvertebrate averages per survey for the island of Tinian were 0.2 COTs, 155.2 sea urchins, 3.6 sea cucumbers, and 0.2 giant clams. Fourteen COTs were observed during all surveys, 11 of them occurring along the southeast side of the island during one survey. The location of the COTs does not suggest active coral predation when compared with the amount of stressed hard corals. Sea urchins were the predominant macroinvertebrate observed with numbers exceeding 1,001 individuals per survey segment on numerous occasions. The highest concentrations of urchins were observed along the west side of the island on continuous reef in the proximity of Gurguan Point. The benthic diver observed populations of over 1,001 urchins on three segments, whereas the remaining segments rarely dropped below 100 individuals. Other large populations of urchins were observed on the east side along the area of Moss Point as well as the southeast end of the island. Sea cucumber and giant clam numbers remained low throughout all surveys at Tinian, with the exception of the northeast region, where an average of 15 sea cucumbers were observed per segment.

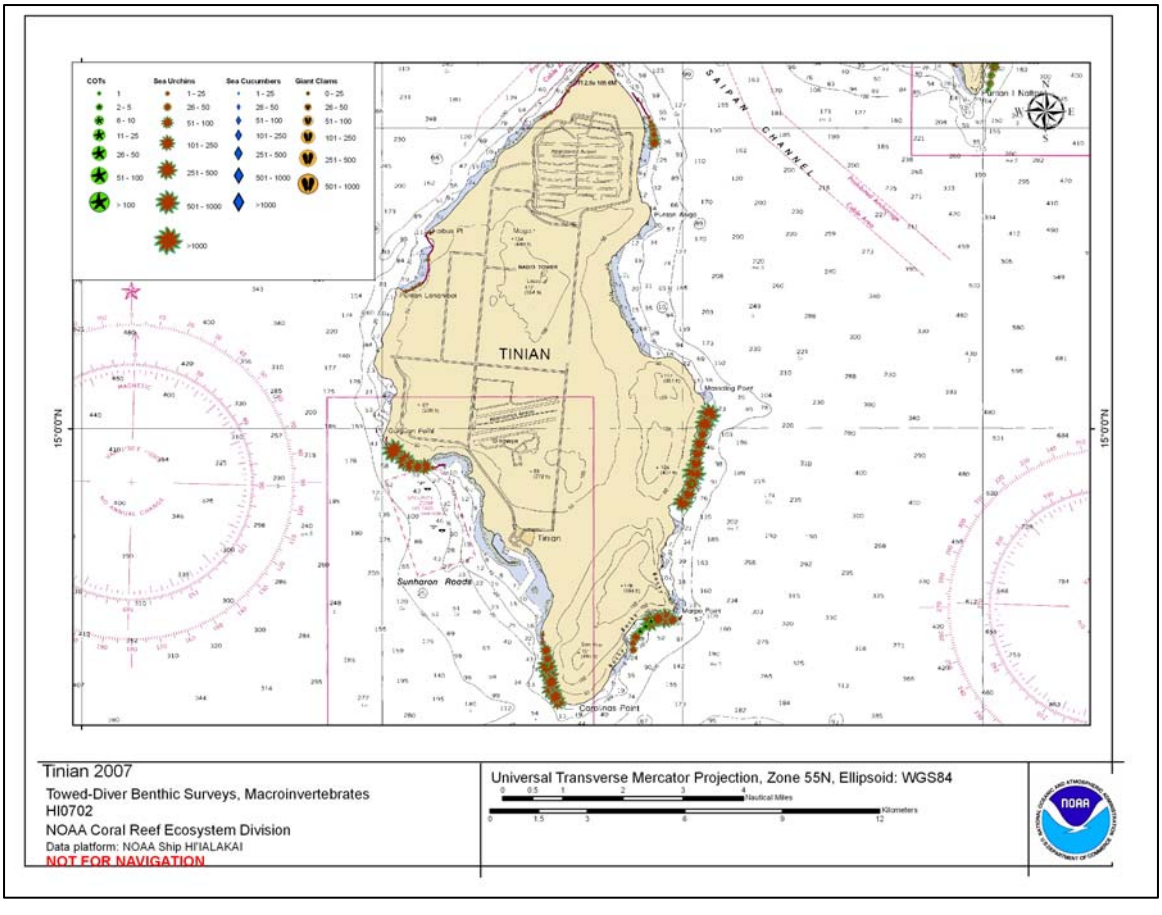

Figure E.4.3.1-1 Towed-diver macroinvertebrate observations at Guam for HI-07-02.

E.4.3.2 Invertebrate Collections

No *Acanthaster planci* were collected around Tinian.

E.5. Fish

E.5.1 REA Fish Surveys

Stationary Point Count data
A total of 20 individual SPC surveys were conducted at 5 forereef sites around the island of Tinian. Divers enumerated fishes from 10 families and 23 species during the survey period. Parrotfishes (Scaridae) were the most abundant family with a biomass of 0.019 ton per hectare. Snappers (Lutjanidae) were the second most abundant fish during the SPCs yielding a biomass of 0.018 ton per hectare. A single shark sighting at site TIN-1 yielded a particularly high overall biomass for this site (0.28 ton/ha), as well as for the overall shark biomass average for the island (0.036 ton/ha).

Belt-Transect data
During the survey period, 15 belt-transect surveys were conducted at 5 forereef sites around the island of Tinian. Divers enumerated fishes from 25 families and 110 species during surveys. Parrotfish were the most abundant fishes with a biomass of 0.093 ton per hectare. Surgeonfish (0.048 ton per hectare) were also very abundant. More than half the biomass on Tinian was composed of herbivorous fish, with very few top predators (Fig. E.5.1-1).

Overall observations
A total of 163 species were observed during the survey period by all divers. The medium to large fish biomass around Tinian during the survey period was 0.11 ton/ha for the SPC surveys (Table E.5.1-1), and the total fish biomass was 0.25 ton/ha for the Belt transect surveys (Table E.5.1-2).

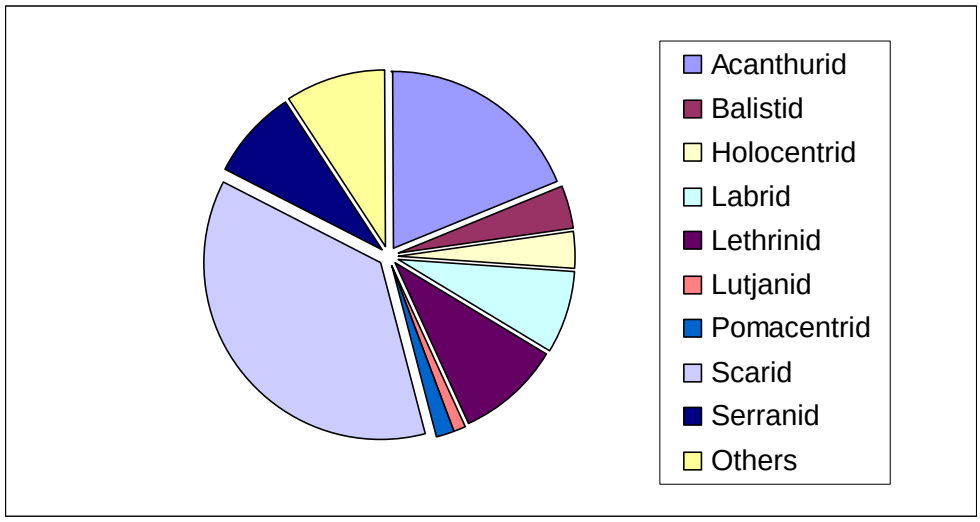

Figure E.5.1-1 Family composition of the total fish biomass (0.25 ton per hectare) around Tinian Island.

Table E.5.1-1. Average of medium to large fish biomass (tail length >25 cm) around Tinian Island (ton per hectare).

Site	Total	Acanthurid	Balistid	Carangid	Diodontid	Hemigaleid	Labrid	Lethrinid	Lutjanid	Scarid	Serranid	Others
TIN-1	0.28	0.000	0.000	0.000	0.000	0.179	0.007	0.000	0.074	0.013	0.012	0.000
TIN-2	0.10	0.010	0.000	0.000	0.051	0.000	0.003	0.004	0.016	0.004	0.009	0.003
TIN-3	0.03	0.000	0.000	0.005	0.000	0.000	0.000	0.004	0.000	0.000	0.007	0.012
TIN-4	0.09	0.025	0.006	0.000	0.000	0.000	0.005	0.015	0.002	0.036	0.000	0.002
TIN-6	0.07	0.012	0.000	0.000	0.000	0.000	0.003	0.004	0.000	0.043	0.004	0.000
Average	0.11	0.009	0.001	0.001	0.010	0.036	0.004	0.005	0.018	0.019	0.007	0.004

Table E.5.1-2. Average total fish biomass around Tinian Island (ton per hectare).

Sites	Total	Acanthurid	Balistid	Holocentrid	Labrid	Lethrinid	Lutjanid	Pomacentrid	Scarid	Serranid	Others
TIN-1	0.35	0.048	0.001	0.000	0.023	0.014	0.000	0.006	0.236	0.010	0.011
TIN-2	0.32	0.040	0.007	0.016	0.008	0.064	0.005	0.003	0.125	0.028	0.020
TIN-3	0.24	0.077	0.012	0.004	0.037	0.013	0.000	0.003	0.020	0.045	0.023
TIN-4	0.21	0.061	0.019	0.000	0.014	0.010	0.007	0.004	0.044	0.013	0.038
TIN-6	0.15	0.013	0.009	0.020	0.015	0.017	0.000	0.006	0.039	0.010	0.023
Average	0.25	0.048	0.010	0.008	0.019	0.024	0.002	0.005	0.093	0.021	0.023

E.5.2 Fish Towed-diver Surveys

At Tinian, the Towboard team conducted seven surveys totaling 17.5 kilometers in length and covering 17.5 hectares of ocean bottom. Mean survey length was 2.5 km. One hundred four fish (>50cmTL, all species spooled) were observed totaling 20 different species. Overall numeric density was 5.94 fish per hectare. Bigeye trevally (*Caranx sexfasciatus*), pickhandle barracuda (*Sphyraena jello*), dogtooth tuna (*Gymnosarda unicolor*), whitetip reef shark (*Triaenodon obesus*) and sleek unicornfish (*Naso hexacanthus*) were the five most commonly observed species (>50 cm TL) at Tinian during the survey period (Table E.5.2-1).

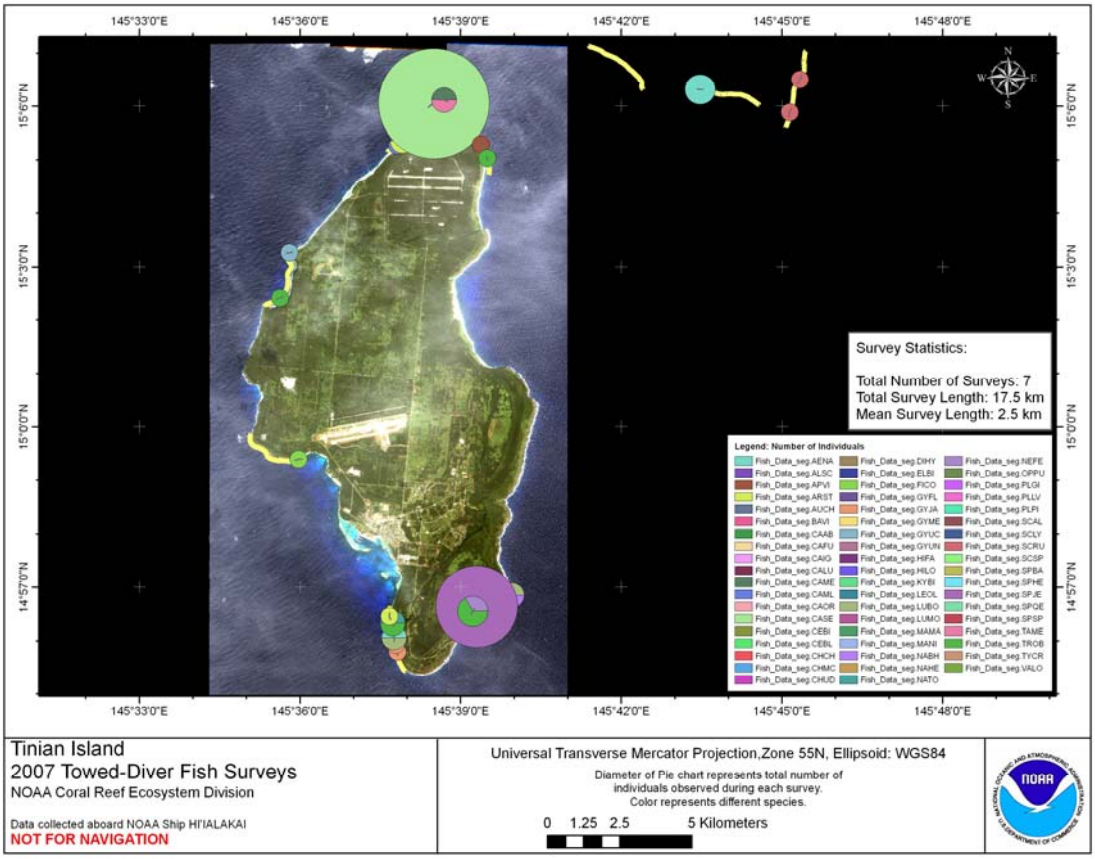

Figure E.5.2-1. Distribution of large fish observations at Tinian.

Table E.5.2-1. Total number of individuals of each species observed at Tinian.

Island	Taxon Name	#
Tinian	Caranx sexfasciatus	40
	Sphyraena jello	22
	Gymnosarda unicolor	11
	Triaenodon obesus	5
	Naso hexacanthus	5
	Lutjanus bohar	4
	Arothron stellatus	2
	Naso tonganus	2
	Gymnothorax javanicus	2
	Carcharhinus melanopterus	1
	Aprion virescens	1
	Fistularia commersonii	1
	Aetobatus narinari	1
	Naso brachycentron	1
	Caranx melampygus	1
	Chlorurus microrhinos	1
	Nebrius ferrugineus	1
	Scarus rubroviolaceus	1
	Aluterus scriptus	1
	Taeniura meyeni	1
Tinian Total		104

Appendix F: Saipan

F.1. Benthic Habitat Mapping

During HI-07-02, multibeam mapping surveys were conducted at Saipan Island and Marpi Bank using the *Hi'ialakai*'s EM300 and the R/V *AHI*'s Reson 8101 multibeam sonars. The *Hi'ialakai* surveyed for 2 ½ days and 2 nights around Saipan, and the *AHI* surveyed for 3 days in the Saipan Harbor. Total coverage by the *Hi'ialakai* at Saipan, Tinian, and Aguijan, combined, was ~1,800 sq. km within water depths ranging between 14 and 2,800 m (Fig. F.1-1).

Prior to HI-07-02, multibeam data were collected by the *AHI* in 2003, completing the banktop of Saipan to depths of ~300 m. During the cruise, the *Hi'ialakai* was able to meet the existing coverage and extend the multibeam maps to depths reaching 2,800 m on the east side of the island and between ~700 and 1,000 m around the rest of the island and around Marpi Bank. About 10 nmi from the Northeast tip of Saipan, previously collected multichannel seismic data from R/V *Maurice Ewing* Cruise EW-02-02 in 2002 reveal a landslide headwall scarp and toe a few kilometers down slope. The *Hi'ialakai* surveyed across the existing data and continued south for about 8 nmi, mapping the scarp and the fault line that crosses it and revealing portions of undercut canyons formed across the fault. The east side of Saipan reach deeper bottom closer to shore via deeply cut canyons that extend from shore. Laulau Bay, on the Southeast side shows highs in the middle of the bay. The channel between Saipan and Tinian is very smooth and, based on the real time backscatter display, is likely covered with thick sand with the exception of a narrow bank (with the shallowest sounding at 103 m) extending past the middle of the channel from Puntan Agingan. The west side of Saipan's bank top extends about 6 to 10 miles offshore forming the area the United States Navy uses for pre-positioned ship anchorage sites. The anchorage was mapped during the 2003 surveys. Beyond the anchorage to the west and north, the seafloor gradually slopes to the abyss. A few deep canyons recede off of the small island just north of the anchorage and a small submerged pinnacle is just west of the southern part of the outside anchorage.

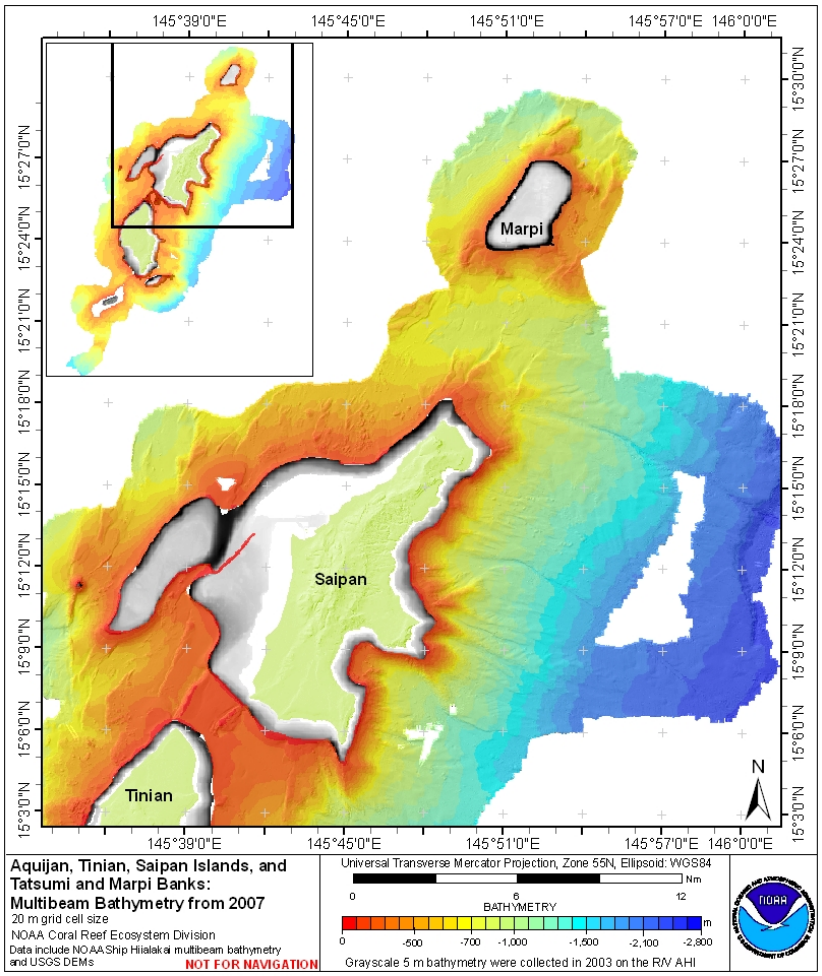

Figure F.1-1: Multibeam bathymetry of Tinian and Saipan, shown with a USGS DEM, and of Aguijan, with a USGS Digital Orthophoto Quadrangle Image.

The R/V *AHI* worked in Saipan harbor with representatives from NOAA's Office of Coast Survey (OCS) to complete nautical charting surveys of the harbor. During the 3 days of surveying they completed multibeam mapping as well as sidescan surveys of the entire harbor. The data from the *AHI* surveys will be processed by OCS and used for nautical chart updates by the end of 2007. A final summary of mapping survey results from the R/V AHI will be presented in a separate report.

F.2. Oceanography and Water Quality

In total, two instruments were recovered and eight instruments were deployed at Saipan during HI-07-02. One subsurface temperature recorder (STR) was recovered and replaced that was originally colocated with a Coral Reef Early Warning System (CREWS) buoy anchor. The CREWS buoy (previously removed by a local agency due to mooring problems) and anchor were recovered but not replaced. A new sea surface temperature (SST) buoy was deployed along the west side of Saipan. Finally, two new

ecological acoustic recorders with attached subsurface temperature recorders were deployed at two marine protected areas on the east side of Saipan, colocated with REA sites 1 and 2. A wave and tide recorder was deployed on the southeast side of Saipan to be used in collaborative work with the oceanography Department of the University of Hawaii at Manoa (Fig. F.2-1).

Thirty-eight shallow water conductivity, temperature, depth (CTD) casts were conducted around the perimeter of Saipan at approximately 1 mile intervals following the 30-m contour. At four of these CTD locations, water sample profiles were performed concurrently, using a daisy chain of Niskin bottles at 1 m, 10 m, 20 m and 30 m depths, for a total of 72 discrete water samples measuring chlorophyll and nutrient concentrations (Fig. F.2-1).

In situ temperature data at 7 m obtained from October 2005 to May 2007 shows seasonal variability with warm temperatures observed from July to November and cooler temperatures from January to April (Fig. F.2-2). In situ data are approximately 0.5 °C warmer than the climatological average from November 2005 to July 2006. This is followed by a particularly warm event during September/October 2006 when temperature was ~1.0 °C above the climatological mean, reaching a maximum of 30.40 °C. Subsequent to this warm period, and for the remainder of the time series, the in situ data follows the climatology rather closely.

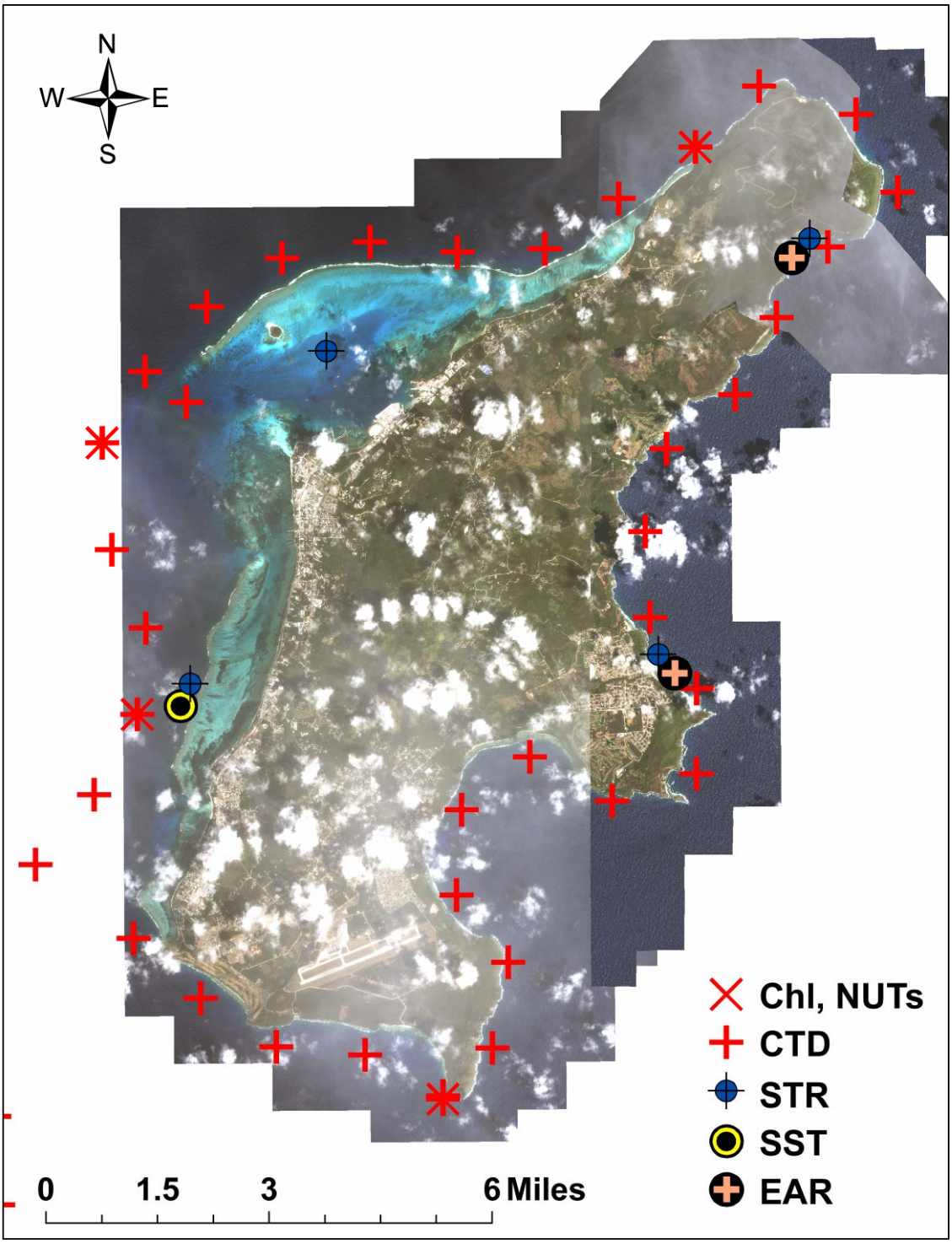

Figure F.5-1. Positions of CTDs, water samples, and moorings at Saipan.

Saipan

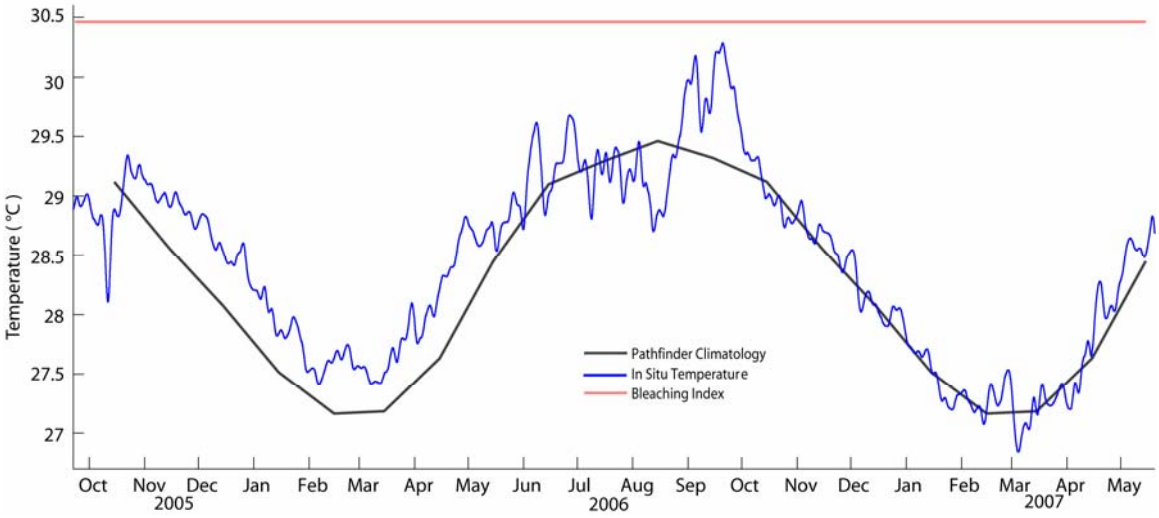

Figure F.2-2. In situ temperature (7 m) time series from Saipan overlaid with Pathfinder SST climatology, and including the coral reef bleaching index.

F.3 Rapid Ecological Assessment (REA) Site Descriptions

Saipan: This is the most developed island in the chain. A majority of the fishing pressure occurs in the western lagoon. The eastern coast is more exposed to rough seas and, therefore fishing is limited to certain times of the year. Cast-netting, spear-fishing, hook and line, gleaning, trolling and bottom fishing are the common fishing techniques practiced on this island. There are five marine protected areas on this island, three no-take marine conservation areas and two species-based reserves. Gill-netting is prohibited in the CNMI, except for traditional events. Scuba spearfishing is banned in the CNMI. There are 10 fish aggregating device systems located within 10 miles of Saipan and Tinian. Watershed-based pollution varies in magnitude, but influences coral reef communities from Marine Beach clockwise to Coral Ocean Point.

REA surveys were conducted at eight sites at Saipan (Table F.3-1). The locations of the REA sites at Saipan are shown in Figure F.3-1.

Table F.3-1. Sites surveyed by REA team at Saipan, HI-07-02, May 2007. Depths and temperature are from Kenyon's dive gauge.

Site #	Date	Latitude (north)		Longitude (east)		Transect depth range, m	Max. depth, m	Temp, ˚C
SAI-1	5/20/07	15	15.542	145	48.901	10.9 - 12.7	15.5	28.3
SAI-2	5/20/07	15	10.577	145	47.279	12.7 - 17.6	18.2	28.3
SAI-3	5/20/07	15	9.364	145	46.185	12.7 - 14.8	15.5	28.3
SAI-5	5/21/07	15	5.877	145	44.613	14.5 - 15.5	16.1	28.3
SAI-7	5/21/07	15	6.500	145	42.372	11.5 - 12.4	13.3	28.3
SAI-6	5/21/07	15	9.399	145	41.408	11.8 - 13.0	13.3	28.3
SAI-8	5/22/07	15	16.452	145	47.470	12.4 -15.5	18.5	28.3
SAI-4	5/22/07	15	15.336	145	43.311	12.1 -12.4	13.9	28.3

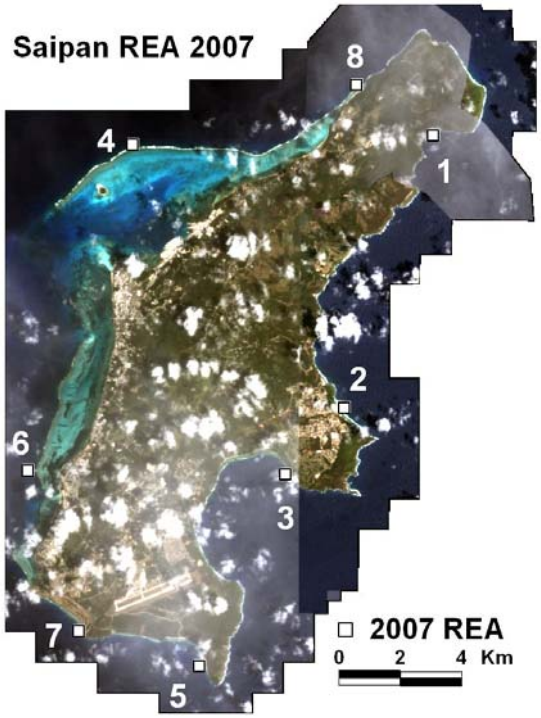

Figure F.3-1. Locations of 2007 REA survey sites at Saipan.

SAI-1
May 20, 2007
Northeast side, off Bird Island, transect depth 36–42 ft. Boulders with sand/rubble, heavily covered with turf algae and light cover *Liagora* and *Padina* macroalgae. Small, thinly scattered coral colonies on boulders. Fourteen genera of scleractinian corals and one octocoral genus enumerated within 50 m^2. Four additional genera (*Oulophyllia, Galaxea, Turbinaria, Psammocora)* seen outside belt transects. Low percent live coral cover: 2.0%. Pavement covered on turf-algae comprised over 55% of benthic cover. Disease and health surveys noted: seven cases of dark discolorations on *Cyphastrea*, and two cases of COTS predation on *Stylophora*. This site is located on the back side of Bird Island in Saipan, and the terrain was a cluster of large boulders, which made for a diverse algal community. The algae surveys report that this community was dominated by *Liagora* sp., *Galaxaura cohaerens*, turf and blue-green algae. *Neurymenia fraxinifolia*, found at this site, was not found south of Saipan during the algae surveys on this trip.

SAI-2
May 20, 2007
East side, Kagman Homestead, transect depth 42–58 ft. Twenty-two genera of scleractinian corals, two octocoral genera, one unknown corallimorph, and one other hexacoral (Palythoa) enumerated within 50 m^2. Four additional genera (*Scapophyllia, Plesiastrea, Coscinaraea, Turbinaria)* seen outside belt transects. *Galaxea* numerically abundant; unknown corallimorph common. Aggregate relief, low percent live coral cover (5.9%). Pavement covered on turf-algae comprised over 75% of benthic cover. Disease

and health surveys noted: two cases of discolorations and irritations were observed on *Porites*, five cases of coralline lethal orange disease, and one case of a potentially new coralline algal disease. Algae surveys report that although turf algae, especially *Tolypocladia calodictyon*, was prevalent in most of the survey quadrats, macroalgae was also very diverse with at least 11 different genera represented. Novel species found here were *Valonia fastigiata, Haloplegma duperreyi,* and an unidentified *Caulerpa* sp. not found in the rest of the Southern Marianas.

SAI-3
May 20, 2007
Southeast side, Laulau area, transect depth 42–49 ft. Eroded carbonate dominated by *Porites rus*; very high cover cyanobacterial films, very degraded appearance. Adjacent shallow reef (<10 ft), however, vibrant with diverse corals (seen snorkeling). Thirteen genera of scleractinian corals enumerated within 50 m^2. Three additional genera (*Plesiastrea, Sinularia, Zoanthus)* seen outside belt transects. Aggregate relief with dead *Porites rus* buildups; moderate percent live coral cover (19.6%), heavily dominated by *Porites rus*. Cyano-bacterial mats growing on the carbonate pavement and rubble comprised nearly 40% of the benthic cover; coralline algae only comprised 4% of the live benthos. Disease and health surveys noted: 12 cases of COTS predation were noted on: *Fungia*, *Goniastrea,* and *Porites*. Additionally, one case of coralline lethal orange disease was detected. Algae surveys report that the transect area was mostly dead pavement or sand covered with cyanobacteria. *Platoma* cf. *ardreanum* along with 11 other species were found during the random swim, mostly during the shallow safety stop.

SAI-5
May 21, 2007
South point, "Boy Scout Beach," transect depth 48–51 ft. High relief and sand channels; dominated by *Porites rus* and helmet-shaped *Porites* colonies. *Porites* colony counts highly interpretive, as high partial mortality makes deciphering the boundaries and size of colonies particularly difficult. Ten genera of scleractinian corals and one octocoral genus enumerated within 50 m^2. Four additional genera (*Herpolitha, Turbinaria, Coscinaraea, Sinularia)* seen outside belt transects. Moderately high percent live coral cover: 33.3%, dominated by *Porites* spp. Pavement covered on turf-algae comprised over 33% of benthic cover. Disease and health surveys noted: five cases of *Porites* pink irritations and discoloration, six cases encrusting sponge overgrowth on *Porites* spp, four cases of coralline lethal orange disease, and 1 case of COTS predation *Porites*. Algae surveys report that this *Porites*-dominated community did not show much algal diversity. Cyanobacteria covered most of the dead pavement bottom. Turf and calcareous algae were present: *Jania capillacea, Amphiroa fragilissima, Halimeda* spp.

SAI-7
May 21, 2007
SW side; Coral Ocean Point, transect depth 38–41 ft. Degraded reef offshore from golf course and other construction. Dead colony structure (especially *Pocillopora* and *Acropora*, many large) still intact but covered with turf algae. Several large (>40 cm diameter) colonies *Pocillopora woodjonesi* in the area still thriving. Nineteen genera of

scleractinian corals enumerated within 50 m^2. Two additional genera (*Leptoseris (mycetoseroides), Sinularia)* seen outside belt transects. Aggregate relief, low percent live coral cover (5.9%). Pavement covered on turf-algae comprised over 63% of benthic cover. Disease and health surveys noted: 18 cases of COTS predation on *Astreopora, Pocillopora*, *Porites*, *Stylophora*, and *Montipora*. Algae surveys report that this site displayed an algal community typical of the rest of Saipan. Cyanobacteria was largely present as were the macroalgae *Amphiroa fragilissima*, *Halimeda* spp., *Caulerpa* spp., *Dictyosphaeria versluyii, Neomeris* spp. and a few other species found sporadically.

SAI-6
May 21, 2007
West side, "Sugar Dock," transect depth 39–43 ft. Carbonate with scattered coral colonies, and sand channels. Several large (>40 cm diameter) colonies *Pocillopora* in the area. Sixteen genera of scleractinian corals and three octocoral genera enumerated within 50 m^2. One additional genus (*Gardineroseris)* seen outside belt transects. Aggregate relief with dead *Porites rus* buildups; moderate percent live coral cover (11.8%), with scattered *Pocillopora*, *Astreopora*, *Porites*, *Goniastrea*, and *Pavona*. Numerous standing dead and eroding colonies of *Pocillopora* spp. Carbonate pavement covered by turf algae represented over 63% of the benthic cover. Disease and health surveys noted two cases of discoloration on *Cyphastrea* and *Porites*, respectively. Additionally, two cases of mild bleaching on *Platygyra*, and seven cases of snail and COTS predation on *Pocillopora, Goniastrea*, *Astreopora*, *Favia*, *Montipora*, and *Stylophora*. Finally, two cases of coralline algae bleaching were detected. Algae surveys report that turf algae and cyanobacteria were prevalent and a few other species were found; *Tricleocarpa fragilis, Amphiroa fragilissima*, *Halimeda* spp., and *Gelidiella pannosa.*

SAI-8
May 22, 2007
NW side, Wing Beach, depth range: 12–16 m. Scoured substrate, low relief with scatted coral colonies; low percent live coral cover (7.8%). Sloping plain of rubble and sand with heavy macroalgae cover. Scattered coral colonies, but high diversity. Twenty-three genera of scleractinian corals and two octocoral genera enumerated within 50 m^2. Pavement covered with turf-algae comprised over 46% of benthic cover, and macroalgae including *Macrodictyon* and *Halimeda* represented 34.3%. Disease and health assessments within the survey area (300 m^2) found four cases of discoloration on *Cyphastrea*, one case of coralline lethal orange disease, and six cases of COTS predation *Porites*.

SAI-4
May 22, 2007
NW side, outside barrier reef, depth range: 12–14 m. Qualitatively very similar to SAI-8. Scoured substrate, low relief with scatted coral colonies; low percent live coral cover (3.9%). Seventeen genera of scleractinian corals, two octocoral genera, one hydrozoan genus, and one other hexacoral enumerated within 50m^2. Pavement covered with turf-algae comprised over 67% of benthic cover; heavy cover of *Halimeda*. Coral disease and

health surveys within the survey area (300 m^2) found one case of cyanobacterial infection on *Pocillopora*, and six cases of COTS predation.

F.4. Benthic Environment

F.4.1. Algae

Tentatively for Guam and the southern CNMI, 45 macroalgae genera were found altogether: 37 known species (16 genera) of green algae (Chlorophyceae), 28 known species (25 genera) of red algae (Rhodophyceae), and 6 known species (4 genera) of brown algae (Phaeophyceae). Also, several unidentified species of filamentous algae were grouped into the functional category of turf algae, and multiple species of cyanobacteria were found. Turf and calcified algae seem to do well on these wave-scoured islands. Subsequent to microscopic examination of samples, it is expected that with the identification of epiphytes and several species of macroalgae the number of species collected will increase substantially. Quantitative sites were all situated in depths of about 35-55 ft, mostly around 40 ft. A comprehensive algae list is shown below in Table F.4.1-1. Further examination of species is needed to increase the accuracy and completion of the list.

Table F.4.1-1. List of putative algae species in the southern Mariana Islands: Guam, Rota, Aguijan, Tinian, and Saipan.

Green algae	**Red algae**
Avrainvaillea erecta	*Amphiroa fragillissima*
Avrainvaillea lacerate	*Actinotrichia* sp.
Boergesenia forbesii	*Asparagopsis taxiformis*
Boodlea vanbosseae	*Botryocladia skottsbergii*
Bornetella oligospora	*Botryocladia tenuissima*
Bryopsis pennata	*Crouania* sp.
Caulerpa biserrulata	*Dichotomaria marginata*
Caulerpa cupressoides	*Galaxaura cohaerens*
Caulerpa elongata	*Gelidiella acerosa*
Caulerpa filicoides var. *andamanensis*	*Gelidiella pannosa*
Caulerpa geminata	*Gelidiopsis* sp.
Caulerpa nummularia	*Gibsmithia dotyi*
Caulerpa spp.	*Gibsmithia hawaiiensis*
Caulerpa racemosa var. *lamourouxii*	*Halymenia dilatata*
Caulerpa sertularioides	*Haloplegma duperreyi*
Caulerpa serrulata	*Jania capillacea*
Caulerpa taxifolia	*Liagora* sp.
Caulerpa webbiana	*Lobophora variegata*
Chlorodesmis hildebrandtii	*Mastophora rosea*

Green algae	Red algae
Codium bulbopilum	*Mesophyllum funagutiense*
Dictyosphaeria cavernosa	*Neurymenia fraxinifolia*
Dictyosphaeria versluysii	*Peyssonnelia inamoena*
Halimeda cuneata	*Platoma* cf. *ardreanum*
Halimeda cf. *discoidea*	*Portieria harveyi*
Halimeda lacunalis f. lata	*Portieria hornemannii*
Halimeda macroloba	*Predaea weldii*
Halimeda macrophysa	*Tolypocladia calodictyon*
Halimeda minima	*Tricleocarpa fragilis*
Halimeda opuntia	UNK SP. 1
Halimeda spp.	UNK SP. 2
Microdictyon setchellianum	UNK SP. 3 (UNK Sp. 2)
Neomeris van-bosseae	UNK SP. 4-red epiphyte
Neomeris spp.	**Brown algae**
Rhipiliopsis sp.	*Dictyota ceylanica*
Tydemania expeditionis	*Dictyota bartayresiana*
Valonia fastigiata	*Hydroclathrus clathrata*
Ventricaria ventricosa	*Padina boergesenii*
Unk. Species	*Turbinaria conoides*
Green mat/fuzz (Unk sp. 1)	*Turbinaria ornate*
Functional groups	
Blue-green	
Turf	
CCA	

The three sites surveyed in 2003 and all eight sites surveyed 2005 were quantitatively resurveyed. *Halimeda* spp. and blue-greens were most dominant in the majority of sites. Other conspicuous algae occurring frequently included *Liagora* spp., *Galaxaura* spp., and *Amphiroa fragilissima*.

Table F.4.1-2: Algal taxa or functional groups recorded in photoquadrats by site at Tinian. First row of numbers indicates the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat.

	SAI-01	SAI-02	SAI-03	SAI-05	SAI-06	SAI-07	SAI-04	SAI-08
GREEN ALGAE								
Boodlea vanbosseae	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.5**	**0.0**
Caulerpa filicoides var. *andamanensis*	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**6.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Caulerpa spp.	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**4.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Caulerpa racemosa var. *lamourouxii*	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**
Caulerpa sertularioides	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Caulerpa serrulata	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**6.0**	**0.0**	**0.0**
Caulerpa webbiana	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Chlorodesmis hildebrandtii	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**
Dictyosphaeria cavernosa	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.0**	**0.0**
Dictyosphaeria versluysii	0.0	8.3	0.0	0.0	0.0	16.7	0.0	16.7
	0.0	**5.0**	**0.0**	**0.0**	**0.0**	**4.0**	**0.0**	**4.5**
Halimeda lacunalis f. lata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**6.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**
Halimeda opuntia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**3.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**0.0**
Halimeda spp.	0.0	41.7	0.0	8.3	25.0	50.0	83.3	91.7
	0.0	**2.8**	**0.0**	**3.0**	**2.8**	**1.9**	**1.2**	**2.4**
Microdictyon setchellianum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91.7
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.5**
Neomeris spp.	0.0	25.0	0.0	0.0	0.0	25.0	16.7	25.0
	0.0	**5.8**	**0.0**	**0.0**	**0.0**	**3.5**	**6.0**	**5.8**

	SAI-01	SAI-02	SAI-03	SAI-05	SAI-06	SAI-07	SAI-04	SAI-08
Rhipiliopsis sp.	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Tydemania expeditionis	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0
	0.0	**0.0**	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Ventricaria ventricosa	0.0	0.0	0.0	0.0	8.3	8.3	0.0	8.3
	0.0	**0.0**	**0.0**	**0.0**	**4.0**	**6.0**	**6.0**	**6.0**
RED ALGAE								
Amphiroa fragillissima	0.0	25.0	41.7	50.0	33.3	33.3	0.0	0.0
	0.0	**5.5**	**2.2**	**2.2**	**3.0**	**2.6**	**0.0**	**0.0**
Crouania sp.	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Dichotomaria marginata	0.0	41.7	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Gelidiella pannosa	16.7	16.7	0.0	0.0	16.7	16.7	0.0	0.0
	5.3	**4.3**	**0.0**	**0.0**	**3.0**	**3.0**	**7.0**	**0.0**
Gibsmithia dotyi	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**
Haloplegma duperreyi	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Jania capillacea	16.7	0.0	0.0	0.0	0.0	0.0	75.0	33.3
	5.0	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**	**4.9**	**4.5**
Liagora sp.	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.6	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Melanamansia glomerata	8.3	41.7	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	**5.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Peyssonnelia inamoena	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Tolypocladia calodictyon	25.0	66.7	0.0	0.0	0.0	0.0	91.7	8.3
	2.5	**2.7**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**4.0**
Tricleocarpa fragilis	58.3	0.0	0.0	0.0	16.7	0.0	0.0	0.0
	1.6	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**	**0.0**
BROWN ALGAE								
Dictyota ceylanica	0.0	8.3	8.3	0.0	0.0	8.3	8.3	0.0
	0.0	**8.0**	**4.0**	**0.0**	**4.0**	**5.0**	**5.0**	**0.0**
Dictyota bartayresiana	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

	SAI-01	SAI-02	SAI-03	SAI-05	SAI-06	SAI-07	SAI-04	SAI-08
Padina boergesenii	33.3	0.0	0.0	0.0	0.0	0.0	33.3	41.7
	4.6	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.6**	**3.4**
FUNCTIONAL GROUPS								
Blue-green	83.3	75.0	83.3	58.3	58.3	58.3	83.3	91.7
	3.2	**4.2**	**1.1**	**1.6**	**1.3**	**1.6**	**3.6**	**3.9**
turf	50.0	83.3	8.3	8.3	33.3	33.3	91.7	58.3
	2.6	**1.6**	**2.0**	**1.5**	**1.8**	**2.4**	**2.0**	**3.4**
CCA	0.0	0.0	25.0	66.7	16.7	25.0	0.0	8.3
	0.0	**0.0**	**1.7**	**1.9**	**2.7**	**2.3**	**0.0**	**6.0**

F.4.1.2 Benthic Towed-diver Surveys – Macroalgae

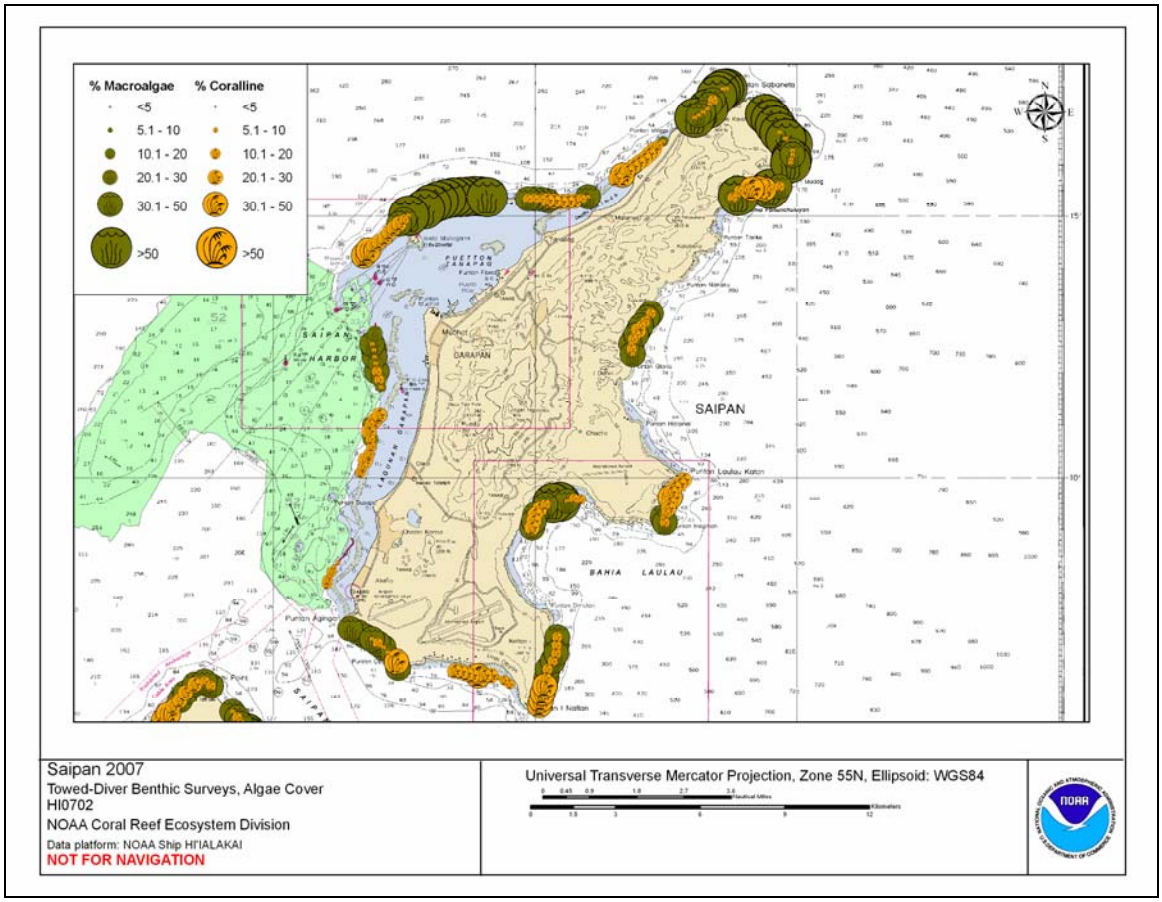

Figure F.4.1.2-1. Macroalgae and coralline algae cover around Saipan (2007).

The macroalgae and coralline algae cover at Saipan averaged 32% and 15% (range 0.1–100% and 0.1–40%, respectively). The highest macroalgae cover (average 68%, range 50.1–75%) was located along the forereef northeast of Isleta Managahana (north coast). The area was classified as continuous reef with gentle slope of mostly medium-low complexity. *Halimeda* and *padina* species were prevalent, with asparagopsis species noted towards the end of the tow. Coralline algae (average 15%, range 5.1–40%) was highest in the area along forereef immediately north of the main channel to Saipan Harbor, passing Isleta Managaha (west side).

F.4.2. Corals

F.4.2.1 Coral Populations

Coral Diversity and Population Parameters

A total of 1,929 cnidarian colonies were enumerated within belt transects covering 400 m^2 at Saipan. These represented 33 cnidarian genera, of which 27 were scleractinian corals, 3 were octocorals (*Sinularia, Lobophytum, Sarcophyton*), 1 was a hydrozoan (*Millepora*), 1 was an additional hexacoral (*Palythoa*), and 1 was an unidentified corallimorph. The number of colonies enumerated and percentage of coral colonies represented by each taxon are shown in Table F.4.2.1-1. Five additional cnidarian taxa (*Scapophyllia, Herpolitha, Leptoseris, Zoanthus, Heliopora)* not seen in belt transects were observed in the larger area around the transects in at least one site surveyed at Saipan. Two genera (*Favia* and *Porites*) each contributed more than 10% of the total number of colonies enumerated.

Table F.4.2.1-1. Number of cnidarians surveyed in belt transects at Saipan in 2007. Taxa contributing more than 10% of the total number of coral colonies are in bold.

Genus	# colonies	% of total
Acanthastrea	6	0.3
Acropora	84	4.4
Astreopora	178	9.2
corallimorph	18	0.9
Coscinaraea	1	0.1
Cycloseris	1	0.1
Cyphastrea	55	2.9
Echinopora	2	0.1
Euphyllia	1	0.1
Favia	210	**10.9**
Fungia	12	0.6
Galaxea	167	8.7
Gardineroseris	3	0.2
Goniastrea	166	8.6
Goniopora	6	0.3
Leptastrea	151	7.8
Lobophytum	17	0.9

Millepora	1	0.1
Montastrea	25	1.3
Montipora	46	2.4
Oulophyllia	4	0.2
Palythoa	4	0.2
Pavona	89	4.6
Platygyra	18	0.9
Plesiastrea	1	0.1
Pocillopora	143	7.4
Porites	346	**17.9**
Psammocora	13	0.7
Sarcophyton	3	0.2
Sinularia	34	1.8
Stylocoeniella	3	0.2
Stylophora	113	5.9
Turbinaria	8	0.4
Total # colonies	1929	
Area surveyed, m^2	400	

Size Class Structure

A size class distribution of all cnidarians enumerated within belt transects at Saipan in 2007 is shown in Figure F.4.2.1-1. The majority (74.7%) of cnidarians were small, with a maximum estimated diameter of less than 10 cm.

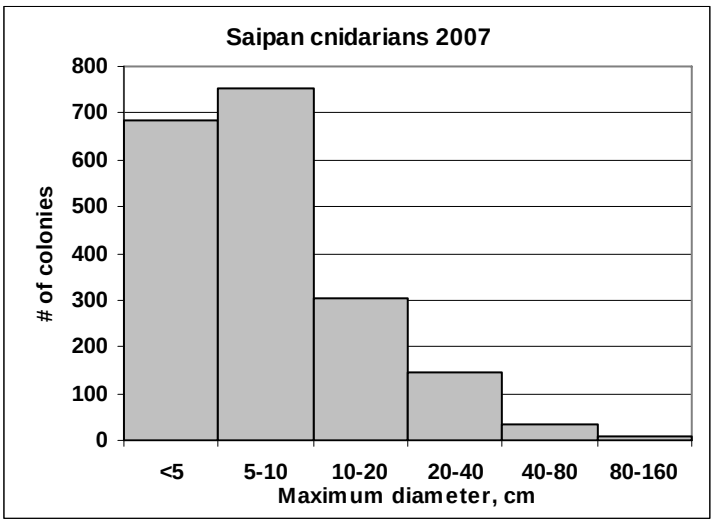

Figure F.4.2.1-1. Size class distributions of cnidarians enumerated in belt transects at Saipan in 2007.

F.4.2.2 Percent Benthic Cover

In 2007, percent benthic cover surveys around Saipan were conducted at eight different sites. The line-intercept methodology quantified a total of 816 points along 400 m of fore-reef communities at depths ranging between 10 and 15 m. Patterns of intra-island variability in percent benthic cover are reflected in Figure F.4.2.2-1. Mean percent live coral cover for all sites combined was moderately low: 11.3 ± 3.7% (mean ± SE). Highest coral cover was recoded at site SAI-5 (33.3%) on the south-facing shore; low percent coral cover (2.0 and 3.9%) was encountered as sites SAI-1 and -4, on the northeast and northwest sides of the island. Turf-algae and fleshy macroalgae including *Halimeda* were particularly abundant at most REA sites; together they comprised nearly 67% of the benthic cover. A total of 11 scleractinian genera were enumerated along the point-count transects, with *Porites* being the most numerically abundant (25.5 ± 3.7%), followed by *Montipora* (12.8 ± 6.3%), *Pocillopora*, and *Leptastrea* (11.9% and 10.8%, respectively). Figure F.4.2.2-2 illustrates the contribution of the different scleractinain genera to the total percent live coral cover.

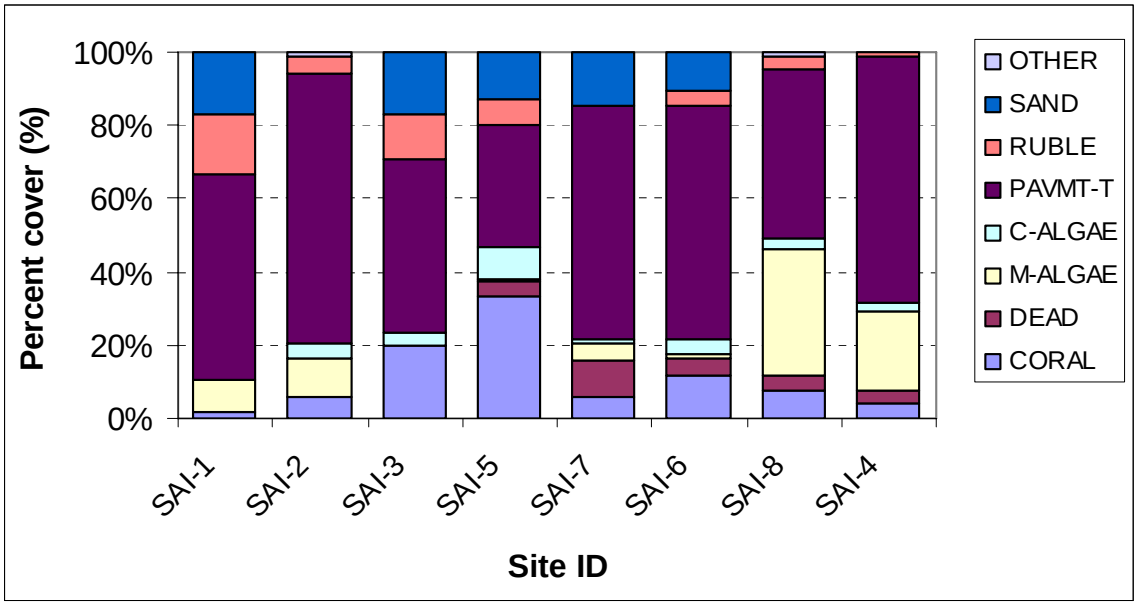

Figure F.4.2.2-1. Mean percent cover of selected benthic elements derived from eight independent REA surveys at Saipan, MAR-RAMP 2007. CORAL: live scleractinian and hydrozoan stony corals; DEAD: dead coral; MALGAE: fleshy macroalgae; CALGAE: crustose coralline algae; PAVMT-T: turf-algae covered carbonate pavement; RUBLE: coral rubble (including recent and old coral rubble covered with turf-algae); SAND: sand; and OTHER: other sessile invertebrates including alcynoarian corals, echinoderms, sponges, tunicates, as well as cyanobacterial mats.

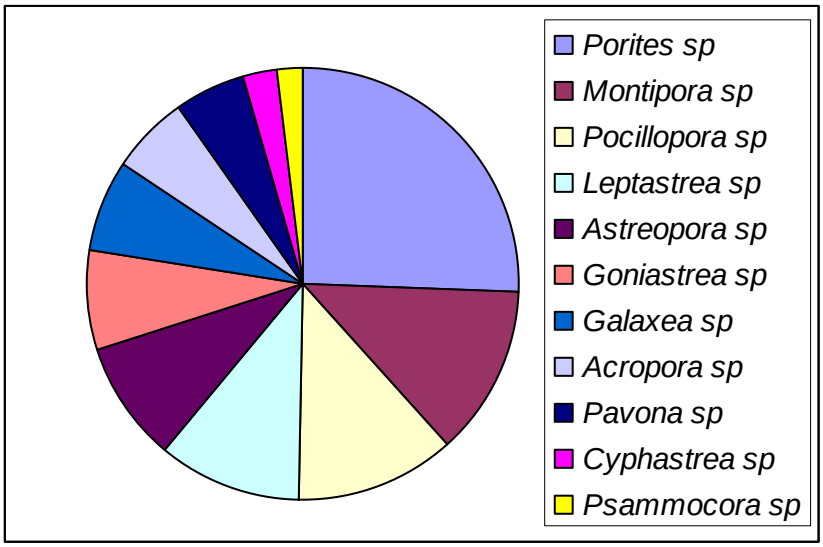

Figure F.4.2.2-2. Percent contribution of the different coral genera to the total live coral cover at Saipan Island, MAR-RAMP 2007.

F.4.2.3 Coral Disease

The coral disease that REA surveyed was a total area of ~2,265 m^2 at eight different sites. A summary of disease occurrence is presented in Table F.4.2.3-1. A total of 29 cases of coral disease were detected within the total area surveyed. Two main health conditions were observed: discolorations and irritations (65%), other lesions (31%); two cases of mild patchy bleaching (6.8%) were also enumerated. Among sites, SAI-5 on the south-facing shore exhibited the greatest occurrence of disease with nearly 35% of cases. Disease conditions, including discoloration and irritations, and other lesions were registered mainly on *Cyphastrea* and *Porites.* Additionally, 14 cases of coralline algal disease and 59 cases of *Acanthaster planci* and snail predation were recorded for all sites combined.

Table F.4.2.3-1 Cumulative number of cases of disease conditions enumerated at each survey site around Saipan Island during the 2007 RAMP cruise. BLE: bleaching; DIS: discolorations other than bleaching; PIR/IRR: *Porites* pink irritations and other coral-algal interactions with pigmentation responses; OTH: other unidentified lesions; PRE: *Acanthaster planci* and *Drupella* predation; CDS: coralline algal discolorations; and CLOD: coralline lethal orange disease. Total survey area ~2,265 m^2.

DZ/HS1	SAI-1	SAI-2	SAI-3	SAI-5	SAI-7	SAI-6	SAI-8	SAI-4
BLE						2		
DIS	7	1		5		2	4	
PIR/IRR		1						
OTH				6				1
PRE	2		12	1	18	7	6	6
CDS		1				1		
CLOD		5	1	4			2	
Grand Total	9	8	13	16	18	12	12	7

F.4.2.4 Benthic Towed-diver Surveys – Corals

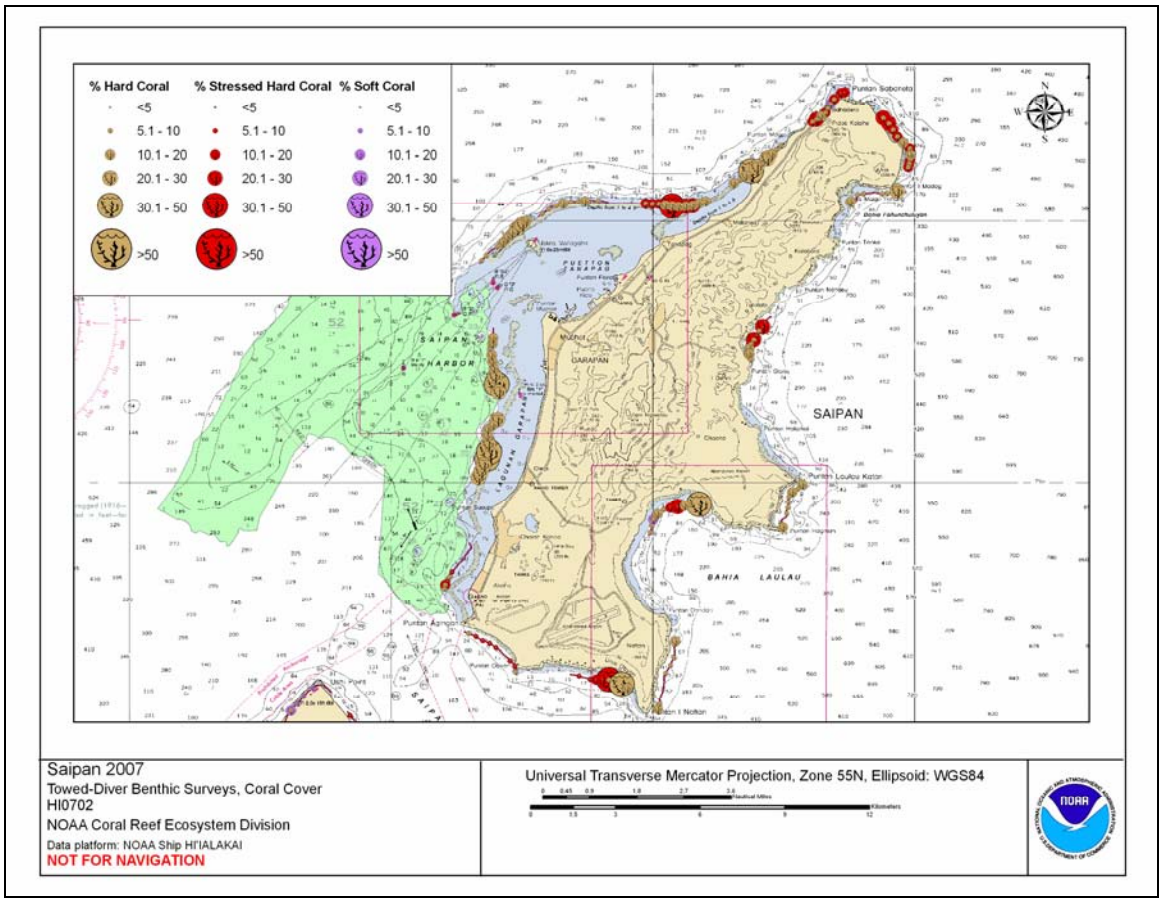

Figure F.4.2.4-1: Hard coral, stressed coral, and soft coral cover around Saipan (2007).

The average hard coral cover for Saipan was recorded at 10% (range 0–40%), with stressed coral averaging 6% (range 0–40%). The highest average coral cover (average 24%, range 10.1–40%) was noted during the towed-diver survey along the forereef off of Oleai and Lagunan Garapan (southwest side). The area was classified as continuous reef with occasional sand channels. Coral cover consisted of encrusting corals, along with *Porites* species (esp. *rus*), *Goniastrea*, and *Pocillopora* species, reaching up to 30.1–40% bottom cover within two time segments.

A number of areas were identified with higher levels of coral stress. The highest average stressed coral (average 16%, range 0.1–40%) was found during a survey north of Tanapag/along the northern coast. The area was characterized as light reef slope, with predominant corals consisting of *Pocillopora*, *Acroporiids* and encrusting corals. *Pocillopora* and *Acropora* heads appeared to have been exposed to predation in 7/10 time segments of the survey. Both pin cushion sea stars (PCS; *Caulerpa filicoides*) and COTs were present for those same time segments, with 23 COTs counted within the transect area over the course of the survey.

Another area of elevated coral stress (average 12%, range 0.1–20%) was observed in the area of North Point/Puntan Sabaneta, tracking past Banadero and ending 0.8 kilometers northeast of Puntan Magpi along the northwest side. COT numbers were low (< 5 individuals/ survey). Elevated PCS densities were noted during the first time segment.

The average soft coral cover for Saipan was 3% (range 0–20%). The highest overall soft coral cover was recorded during the towed-diver survey along the north coast of Bahia Laolao (average 8%, range 1.1–20%). No additional observations were noted.

F.4.3 Macroinvertebrates

F.4.3.1 Benthic Towed-diver Surveys - Macroinvertebrates

The average numbers of macroinvertebrates recorded per survey at Saipan were as follows: 0.3 COTs, 46.4 sea urchins, 7.5 sea cucumbers, and 0.2 giant clams. A total of 42 COTs were observed during 16 50-minute surveys with the highest concentration occurring along Tanapag on the northwest and west sides of Saipan, where 22 individuals were recorded. Divers noted the presence of pin cushion sea stars in almost every segment along this coast as well, which was also the location of the greatest amount of stressed hard corals (as high as 30%). The only consistently high population of sea urchins occurred along the northwest tip of the island, where an average of 295 urchins was observed every segment. The terrain at this location was predominantly a steep wall with a number of small holes for the urchins to bore into. There was also one instance along the northeast side where urchin numbers averaged 181, and cucumbers averaged 69 per segment. Giant clams numbers remained low with the highest average number per segment never exceeding 1. There was one segment along the east side of the island where six were observed within a single segment, but otherwise giant clams were scarce.

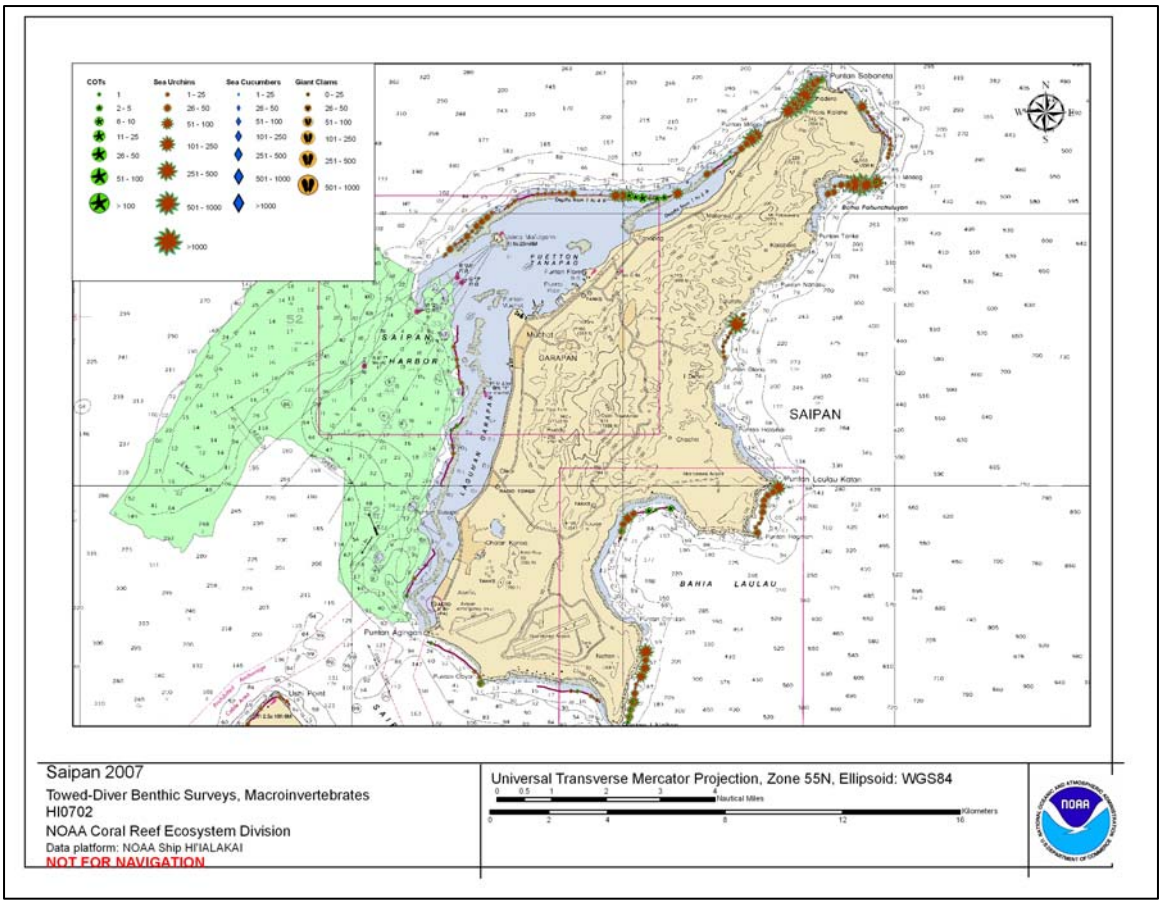

Figure F.4.3.1-1 Towed-diver macroinvertebrate observations at Guam for HI-07-02.

F.4.3.2 Invertebrate collections

Acanthaster planci was collected at one location around Saipan.

Location	Date	Collector	Species	# of Samples	REA site	Site location	Habitat	Depth-ft	Lat deg	Lat min	Lon deg	Lon min
Saipan	5/20/2007	Russell Moffitt	*Acanthaster planci*	3	SAI-3	SE Side, Kaulau Area	Forereef	20 - 45	15	9.364	145	46.185

F.5. Fish

F.5.1 REA Fish Surveys

Stationary Point Count data

A total of 32 individual SPC surveys were conducted at 8 forereef sites around the island of Saipan. Divers enumerated fishes from 16 families and 50 species during the survey period. Snappers (Lutjanidae; e.g., *Lutjanus bohar*) were the most abundant family with a

biomass of 0.035 ton per hectare. Groupers (Seranidae) and wrasses (Labridae) were also commonly observed during the SPCs yielding a biomass of 0.009 and 0.008 ton per hectare, respectively. Notable observations included white-tip sharks at sites SAI-3 and SAI-7. Sharks were rarely seen on or off the survey area around Saipan.

Belt-Transect data

During the survey period, 24 belt-transects were conducted at 8 forereef sites around the island of Saipan. Divers enumerated fishes from 24 families and 126 species during surveys. Parrotfishes were the most abundant fishes with a biomass of 0.037 ton per hectare. Surgeonfishes (0.031 ton per hectare) were also relatively abundant. Herbivorous fishes (parrotfishes and surgeonfishes) comprised almost half of the biomass around the island (Fig. F.5.1-1).

Overall observations

A total of 195 species were observed during the survey period by all divers. The medium to large fish biomass around Saipan during the survey period was 0.09 ton/ha for the SPC surveys (Table F.5.1-1), and the total fish biomass was 0.16 ton/ha for the belt transect surveys (Table F.5.1-2).

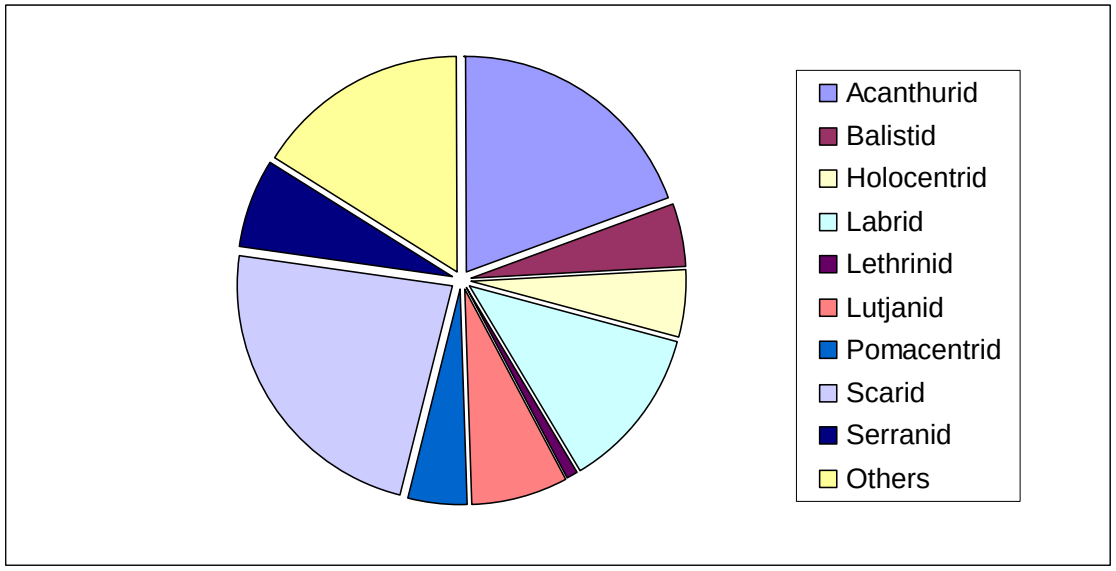

Figure F.5.1-1. Family composition of the total fish biomass (0.16 ton per hectare) around Saipan Island.

Table F.5.1-1. Average biomass of medium to large fish biomass (tail length >25 cm) around Saipan Island (ton per hectare).

Site	Total	Acanthurid	Balistid	Carangid	Diodontid	Hemigaleid	Labrid	Lethrinid	Lutjanid	Scarid	Serranid	Others
SAI-1	0.27	0.005	0.016	0.009	0.000	0.000	0.013	0.000	0.058	0.173	0.000	0.000
SAI-2	0.05	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.012	0.000	0.005
SAI-3	0.02	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.014	0.000	0.000
SAI-4	0.08	0.015	0.028	0.000	0.000	0.000	0.002	0.000	0.008	0.010	0.000	0.013
SAI-5	0.11	0.000	0.000	0.000	0.027	0.000	0.000	0.035	0.002	0.013	0.011	0.025
SAI-6	0.04	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.012	0.016	0.000	0.003
SAI-7	0.09	0.010	0.006	0.000	0.000	0.000	0.005	0.015	0.009	0.035	0.003	0.004
SAI-8	0.10	0.000	0.000	0.000	0.000	0.018	0.006	0.000	0.005	0.052	0.018	0.018
Average	0.09	0.006	0.006	0.001	0.003	0.005	0.007	0.013	0.035	0.008	0.009	0.09

Table F.5.1-2. Average total fish biomass around Saipan Island (ton per hectare).

Sites	Total	Acanthurid	Balistid	Holocentrid	Labrid	Lethrinid	Lutjanid	Pomacentrid	Scarid	Serranid	Others
SAI-1	0.33	0.042	0.006	0.012	0.044	0.000	0.073	0.004	0.108	0.011	0.027
SAI-2	0.12	0.036	0.000	0.006	0.004	0.000	0.006	0.007	0.042	0.005	0.018
SAI-3	0.18	0.021	0.000	0.004	0.035	0.004	0.000	0.009	0.032	0.009	0.063
SAI-4	0.10	0.021	0.024	0.000	0.008	0.000	0.000	0.008	0.005	0.019	0.010
SAI-5	0.18	0.052	0.010	0.029	0.028	0.000	0.007	0.006	0.030	0.009	0.012
SAI-6	0.13	0.038	0.000	0.007	0.009	0.000	0.000	0.009	0.046	0.003	0.016
SAI-7	0.17	0.028	0.010	0.007	0.017	0.006	0.004	0.011	0.029	0.018	0.044
SAI-8	0.05	0.008	0.007	0.000	0.010	0.000	0.000	0.003	0.000	0.012	0.012
Average	0.16	0.031	0.007	0.008	0.019	0.001	0.011	0.007	0.037	0.011	0.025

F.5.2 Fish Towed-diver Surveys

At Saipan, the Towboard team conducted 16 surveys totaling 37 kilometers in length and covering 37 hectares of ocean bottom. Mean survey length was 2.3 km. Three hundred ninety-two fish (>50 cm TL, all species spooled) were observed totaling 29 different species. Overall numeric density was 10.59 fish per hectare. Garden eels (*Conger sp.*) were the most abundant species observed during the survey period and are not shown in Figure E.5.2.1. Aside from *Conger sp.*, bigeye trevally (*Caranx sexfasciatus*), barracuda (*Sphyraena sp.*), bluefin trevally (*Caranx melampygus*), redlip parrotfish (*Scarus rubroviolaceus*) and longnose parrotfish (*Hipposcarus longiceps*) were the five most numerous species (>50 cm TL) at Saipan during the survey period (Table E.5.2-1).

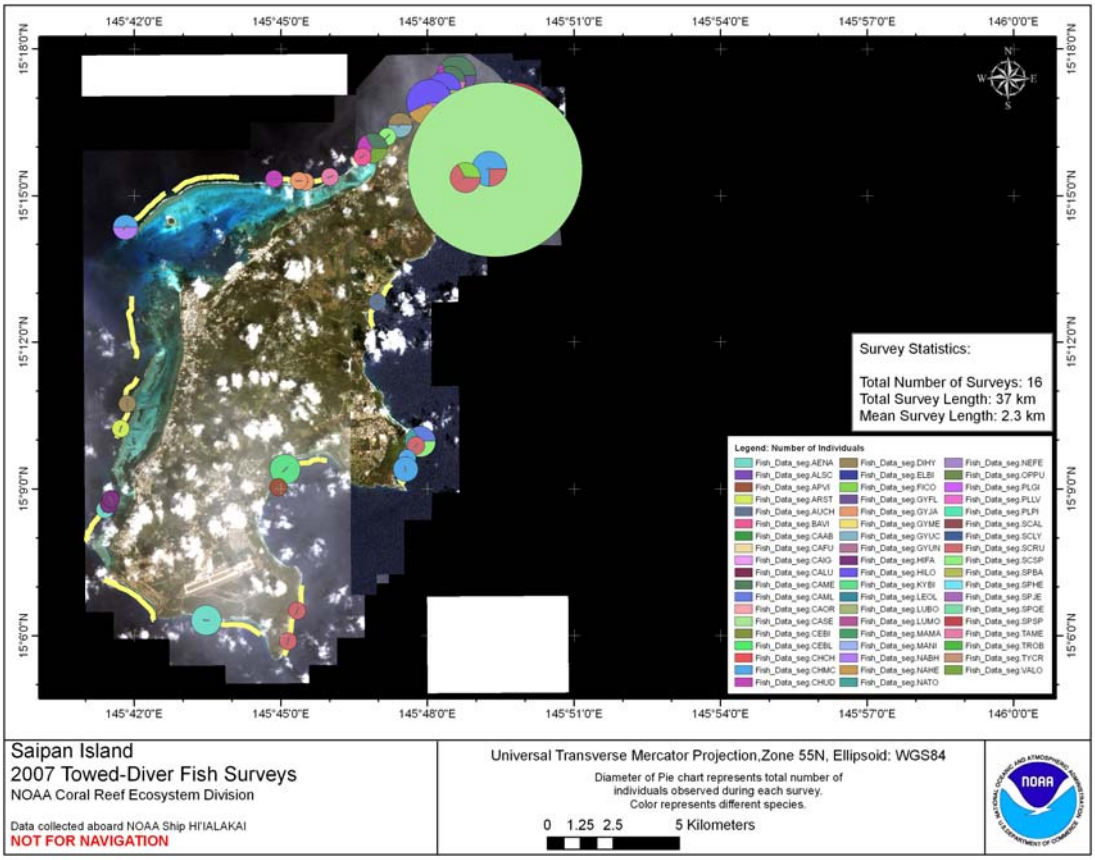

Figure E.5.2-1. Distribution of large fish observations at Saipan.

Table E.5.2-1. Total number of individuals of each species observed at Saipan.

Island	Taxon Name	#
Saipan	Conger sp.	200
	Caranx sexfasciatus	100
	Sphyraena sp.	21
	Caranx melampygus	9
	Scarus rubroviolaceus	7
	Hipposcarus longiceps	7
	Chlorurus microrhinos	7
	Lutjanus bohar	4
	Aetobatus narinari	4
	Cheilinus undulatus	4
	Naso hexacanthus	3
	Kyphosus bigibbus	3
	Taeniura meyeni	2
	Scarus sp.	2
	Diodon hystrix	2
	Gymnothorax flavimarginatus	2
	Gymnothorax javanicus	2
	Himantura fai	2
	Variola louti	1
	Aulostomus chinensis	1
	Carcharhinus melanopterus	1
	Naso brachycentron	1
	Aprion virescens	1
	Naso tonganus	1
	Plectorhinchus gibbosus	1
	Balistoides viridescens	1
	Gymnosarda unicolor	1
	Arothron stellatus	1
	Fistularia commersonii	1
Saipan Total		392